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VOL. 12 SEPTEMBER, 1924 No. 1

LARGE SUPPLY MAINS[1]

By DABNEY H. MAURY[2]

Not many decades ago the cities and towns of this country got their water supply from wells or surface sources close at hand. The rapid growth of urban population has compelled one city after another to go further afield for its water supply. In some cases the capacity of the adjacent wells or stream or lake became inadequate to meet the demands of the community. More often, however, the pollution of the local supply made it necessary to seek another and more distant source.

Conspicuous examples of American cities which have gone far afield for water are Los Angeles, which brought in a new supply from 235 miles away; San Francisco, 154 miles; New York, 120 miles; Tulsa, Oklahoma, 60 miles; Phoenix, Arizona, 32 miles; Butte, Montana, 27 miles; Denver, 25 miles; and Norfolk and Portsmouth, Virginia, about 20 miles each.

In Canada, the city of Winnipeg brought in a new supply a total distance of 98 miles, while Victoria went 38 miles for its water.

In Australia the Coolgardie pipe line is 351 miles in length, while the Apulian Aqueduct now being constructed to supply 266 communities in southern Italy will have 152 miles of main trunk conduit and 841 miles of main and subsidiary branches leading therefrom.

[1] Presented before the New York Convention, May 21, 1924.

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Many other instances could be cited, and their number is increasing rapidly. At least one other pipe line, of more than 100 miles in length, is already under contemplation in this country.

Enough has been said to show that the near future will see a very large amount of capital invested in supply mains, and that the economic design of these mains is a live and important problem.

It will be the purpose of this paper to describe briefly the principal types of pipe available for large supply mains, to present approximate estimates of their respective first costs for various diameters and pressures, to set forth their respective advantages and disadvantages, and to endeavor to put a financial value on these advantages and disadvantages, to the end that the several pipes may ultimately be compared on a dollar-and-cent basis.

HISTORICAL

Cast iron pipe

The earliest recorded use of cast iron water mains appears to have been in Versailles, France, where several miles of cast iron pipe in lengths of one meter, and with flanged joints, were installed between 1685 and 1688, or more than 235 years ago. These mains are reported to be still in service. A number of other cities in France, as well as cities in Belgium, Holland, Germany, Austria and England laid cast iron mains more than 100 years ago.

The Gas Light Company of Baltimore, which was founded in 1816, installed cast iron bell and spigot mains immediately thereafter; while the City of Philadelphia laid cast iron bell and spigot water mains as early as 1817. Troy installed cast iron water mains at least as early as 1833; Boston in 1848; New York at some time prior to 1850, and Toronto in 1854. It is quite possible that there are some other American cities which laid cast iron mains earlier than any of these just mentioned, with the exception of Baltimore and Philadelphia.

Following the earlier installations above recorded, the use of cast iron bell and spigot pipe, especially for water works and gas distribution systems, increased so rapidly in this country as to become almost universal.

Steel pipe

Although steel has of late years been the material commonly used for wrought pipe, it was preceded in this field by wrought

iron. The first pipes or tubes made were apparently used for gun barrels, the bent plates for which were laboriously welded together by hand over a mandrel.

In 1812 an Englishman named Osborn patented machinery for welding and making barrels of firearms and other cylindrical articles. A little later another Englishman, Murdoch, collected and used old gun barrels, screwing them together into a continuous tube for conveying gas, the process of making gas from coal having recently been invented.

In 1824 James Russell devised improvements in the manufacture of tubes for gas and other purposes.

In 1825 Cornelius Whitehouse invented a process of butt-welding wrought iron tubes.

The growing demand for tubular products was met by the establishment of more and more plants for making them, and to the firm of Morris, Tasker & Morris of Philadelphia belongs credit for having built, in 1830-1834, the first furnace in the United States for making butt-welded pipe. In 1836 the same firm erected other plants, including furnaces, mills and machine shops.

In 1847 James J. Walworth sailed to England to investigate the tube making industry in that country, and the year 1849 saw the manufacture of 1-inch pipe, $\frac{3}{4}$-inch pipe and 3-inch flues.

The small plant which formed the nucleus of the many enormous works of the present National Tube Company was established in East Boston in 1868.

While the use of riveted pipe in this country dates back about three-quarters of a century, no such accurate records are available with regard to it as have been secured with regard to cast iron pipe and welded pipe by the efficient publicity departments of the United States Cast Iron Pipe & Foundry Company, and the National Tube Company.

Mr. S. B. Morris, in his paper read before the California Section of the American Water Works Association in 1923, mentions a 30-inch 12-gauge riveted iron pipe laid in 1868, some of which continued in full service for fifty-four years.

At the Philadelphia Convention in 1922 Mr. Theodore A. Leisen cited a 50-inch riveted pipe installed at Pittsburgh in 1871, a 62-inch riveted steel pipe installed for the Detroit Water Works at least forty-seven years ago, a 50-inch riveted steel main laid in Allegheny, Pa., twenty-nine years ago; a 48 inch riveted steel pipe

laid near Newark, N. J., twenty-nine years ago; and 4 miles of 43-inch and 48-inch Lock-Bar steel mains laid in Wilmington, Del., nineteen years ago. Other and earlier large installations of lock-bar pipe are the 12 miles of 15-inch, 24-inch and 26-inch pipe laid in 1897 for the City of Adelaide, Australia; and the famous Coolgardie, Australia, line, 351 miles long and 30 inches in diameter. Perhaps the best known early example of riveted mains for municipal water supply is the Rochester conduit, consisting of 9.62 miles of 36-inch and 2.92 miles of 24-inch wrought iron pipe, laid in 1875.

There are now scores of large cities in this country using wrought iron or steel mains of considerable length and size for water supply or distribution. Some of these mains are riveted, some are of spiral pipe, some are of the lock-bar type, some, of relatively small size, are lap-welded; and a few of the later ones are of the new hammer-weld type, which is the most recent development in the art of making large steel pipe.

Concrete pipe

Precast reinforced concrete pipe has been in use for sewers for 40 or 50 years, taking the place of the larger sizes of vitrified tile pipe and of the smaller sizes of brick masonry or monolithic concrete sewers. It was not until about 30 years ago that serious efforts were made to develop a precast reinforced concrete pipe for conveying water under pressure. The earlier pipes had cement joints like those of tile pipes; joints were developed later in which the cement was applied around a steel mesh projecting from the ends of the pipe. Conduits built of pipe so constructed were naturally too rigid to allow much contraction or settlement.

Within the last decade, however, great improvements have been made in precast reinforced concrete pipe for water supply, and there are now available pipes of this material in 12-foot lengths having unusally smooth interior surfaces, and joints made with lead gaskets which will permit, without material leakage, a relatively large amount of expansion, contraction or settlement. These pipes can be had over a wide range of diameters and for heads up to at least 250 feet.

Wood pipe

The earliest supply mains in common use in this country were bored logs, some of which were doubtless installed more than two

hundred years ago. A number of them remained in service for more than fifty years. These bored logs at first had no metal reinforcement, but, in the course of time, manufacturers began to strengthen the ends of the logs with steel bands.

In 1860 a patent was granted to Mr. A. Wyckoff, of Elmira, New York, for an auger which bored a log, taking out a core in such a manner that the core itself could be rebored with a smaller auger, thus enabling two or more pipe shells of different sizes to be made from one log.

The earliest recorded instance of a built-up pipe of any considerable size, consisting of wooden staves held in place by steel or iron bands, is that of a penstock 6 feet in diameter which was installed in 1874 at Manchester, New Hampshire, by the late Mr. J. T. Fanning, one of the best known hydraulic engineers of his time. This penstock, which was probably of white pine, then quite abundant, is said to have remained in service until 1913.

For the first introduction of continuous wood stave pipe on a larger scale, credit is due to Mr. C. P. Allen, Chief Engineer of the Denver Union Water Company, who, beginning about 1880, built many miles of wood stave pipe of a type which embodies most of the essential features of design now found in the best modern continuous wood stave pipe. The shoes now used for joining the ends of the bands on continuous wood stave pipe follow closely the early designs of Mr. Allen, and are frequently referred to as the "Allen" type of shoe.

A few years later the construction of wood stave pipe was undertaken on a commercial basis by companies in New York and Michigan, which used white pine for their staves, and shortly thereafter, by several companies on the Pacific Coast, using redwood and fir.

As a result of the formation of these companies, the commercial manufacture of machine banded or wire wound pipe had its origin, some of the manufacturers banding their pipes with flat iron or steel hoops wound spirally around the staves, while others used round wire for the same purpose. Very large quantities of wood stave pipe of the machine banded type, as well as of the continuous stave type, are now in use, especially in the western portions of the United States, although within the last few years the war necessities of the country and the tremendous increase in the prices of cast iron and steel pipe have resulted in the introduction of hundreds of miles of wood stave pipe in territory east of the Rocky Mountains. Over

700 miles of wood pipe, from 6-inch to 30-inch in diameter, were installed under the author's direction for the camps, cantonments and other war activities of the United States Army. Many pipe lines of much larger size are now in use either as supply lines to cities or as penstocks for hydro-electric installations. Many of these lines are more than 6 feet in diameter and some of them are as large as 14 feet.

There are also some cities or towns in which machine banded wood stave pipe is in use for distribution mains, and with what are said to be satisfactory results. A notable example is Valparaiso, Indiana, whose entire distribution system is of machine banded Michigan pine pipe. But because wood stave pipe is less durable than cast iron pipe, and, as a rule, leaks much more, it is not usually considered good practice to lay it under pavements, as these pavements would have to be cut and renewed at great expense whenever a leak occurred.

PIPES NOW AVAILABLE

As a result of all of these developments, the engineer charged with the design of a supply main has at the outset four principal materials to choose from; viz., cast iron, steel, reinforced concrete, and wood.

In the case of each material, there are two or more types of pipe at his disposal. For instance, he has available cast iron bell and spigot pipe, made in accordance with the Standard Specifications of the American Water Works Association or of the New England Water Works Association; or, over a limited range of small sizes, he can have the same sort of pipe made by the centrifugal process; or, he can use what is known as the "high tensile strength" bell and spigot cast iron pipe.

In steel pipe the principal types would be riveted, spiral, lock-bar, and hammer-weld pipe, with various types of joints.

If he should decide to make his supply main of reinforced concrete, he could build either a monolithic concrete conduit, or adopt one of several types of precast concrete pipe, with joints at intervals of from 3 to 12 feet.

In the field of wood stave pipe, he could use a pipe of the machine banded type for sizes up to 24-inch, and pipe of the continuous stave type for sizes 20-inch and larger. The staves themselves might be either redwood, fir or pine.

PROCESS OF MANUFACTURE

Cast iron

The first cast iron mains laid abroad were flanged pipe. The earliest bell and spigot pipes laid in America came from abroad, were made in lengths of from 3 to 6 feet and were cast on the side. Somewhat later bell and spigot pipes were made in 9-foot lengths and cast in a sloping position. Still later the length was increased to 12 feet and the pipes were cast vertically, with the bell end up. Some bell

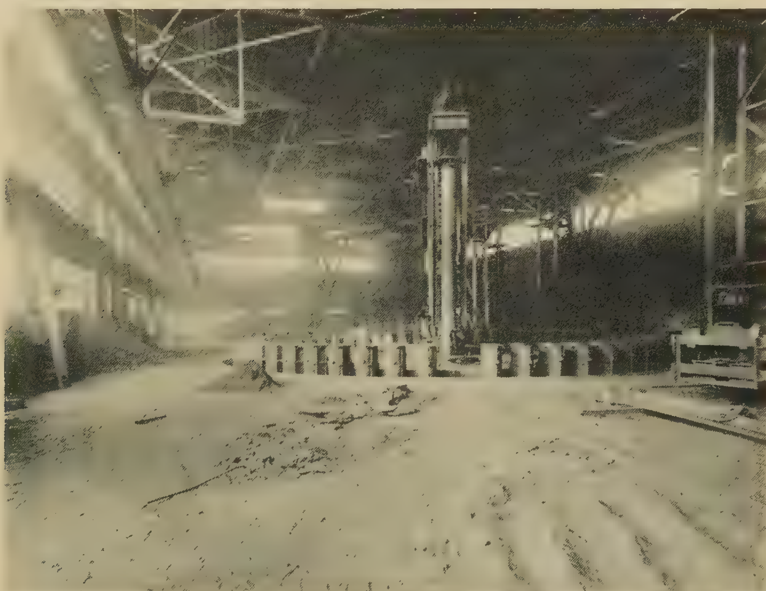


FIG. 1. CASTING PIPE VERTICALLY

and spigot pipes have been made in 16-foot lengths. Standard bell and spigot pipe are at present usually cast with the bell end down. A surplus of metal is poured on top of the spigot end, and this surplus, which carries most of the impurities, is then cut off, leaving the spigot sound and true.

Figure 1 shows the modern method of casting pipe in a vertical position.

The cores for pipe casting are made by wrapping ropes of straw around drums of the proper size and plastering a smooth surface of

FIG. 2. MAKING STRAW ROPES

FIG. 3. WINDING STRAW ROPES ON CORE

clay over the straw. Figure 2 shows the method of making the straw ropes, and figure 3, the winding of the straw ropes on the drums.

The so-called high tensile strength cast iron pipe is made in exactly the same manner as the standard bell and spigot pipe, but the chemical constituents of the cast iron are so changed as to add about 30 per cent to its tensile strength, thus reducing the thickness of shell required for any given head. The pipe so made costs somewhat less, but is a trifle more brittle than the standard cast iron pipe.

FIG. 4. MAKING CENTRIFUGAL PIPE

In the centrifugal process, which has been developed within the last few years, and which is illustrated by figure 4, the molten metal is run into a rapidly revolving mould in the far end of which there has first been placed a core of the shape of the inside of the bell end of the pipe. The revolving mould is contained within a drum which can be moved longitudinally, and which provides a jacket for water-cooling the outer surface of the mould.

While the bell end of the pipe is being poured, the drum and mould are so placed that the cantilever pouring spout extends into the mould as far as the bell; and when the bell has been poured, the drum, with

the mould still revolving inside of it, is backed off gradually until the spout has been withdrawn to the spigot end. The pouring then ceases, but the mould continues to revolve for a short time until the metal has solidified. When the pipe is withdrawn from the mould, as shown in figure 5, the process is repeated. The metal of pipe made by the centrifugal process has greater density than the metal of cast pipe and has nearly double the tensile strength. This reduces the weight of metal required for any given head. Up to date, centrifugal pipe is made in sizes from 6-inch to 12-inch.

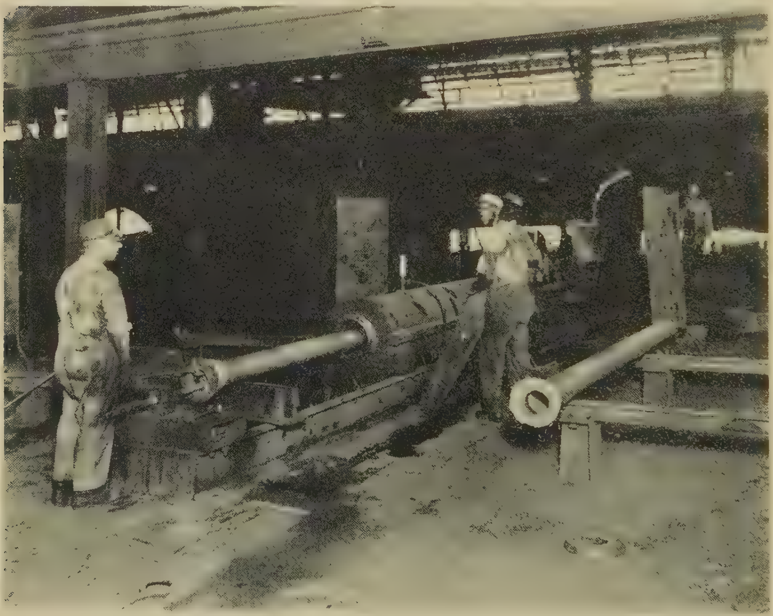


FIG. 5. WITHDRAWING PIPE FROM CENTRIFUGAL MOULD

Steel pipe

In the well known Lock-Bar pipe two plates, the longitudinal edges of which have been slightly upset, are bent to form the two halves of a cylinder. Two bars, each having deep grooves in its sides, are fitted over the adjacent edges of the pair of plates and the sides of the grooves are then squeezed firmly, as shown in figure 6, so as to grasp and hold the upset edges. The longitudinal joint thus formed is considerably stronger than any riveted joint, and

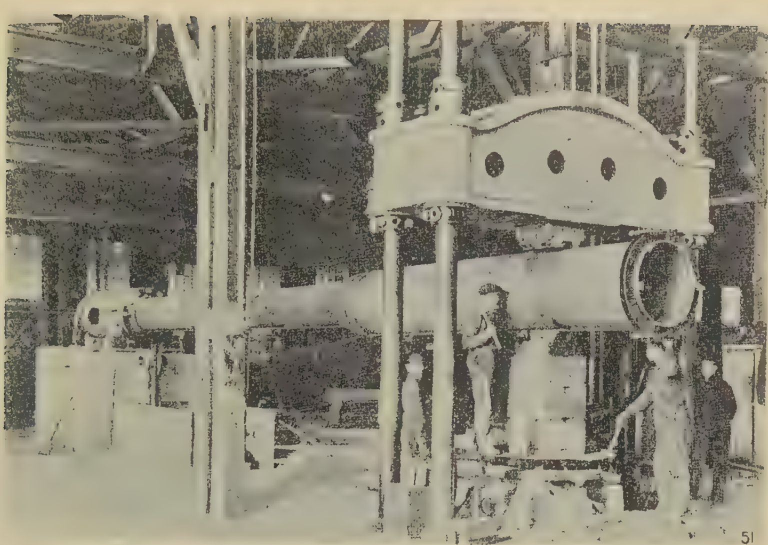


Fig. 6. Making Lock-Bar Pipe

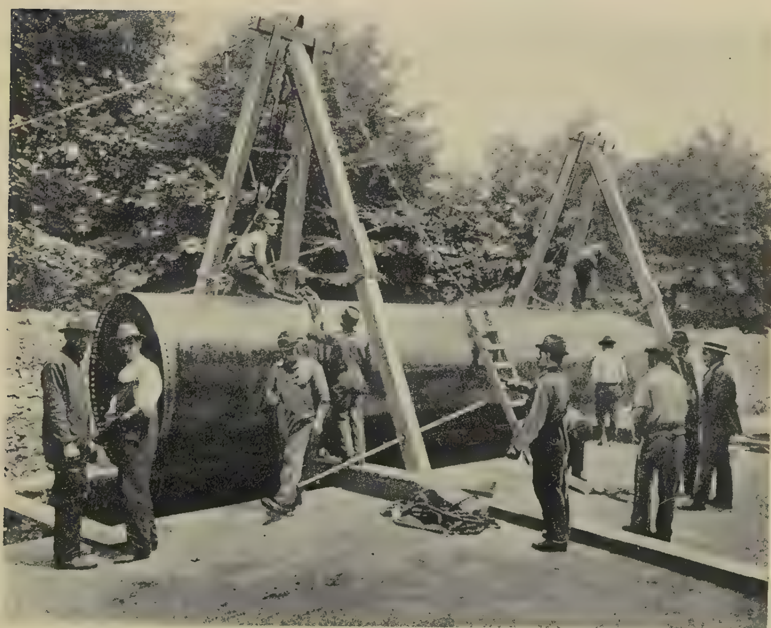


Fig. 7. 72-Inch Lock-Bar Pipe

somewhat stronger than the average welded joint, the lock-bar joint being actually about as strong as the plate itself. Figure 7 shows a 72-inch pipe of this type being laid in the Catskill Aqueduct System.

The circumferential joints of lock-bar pipe are usually made by tapering each length of pipe slightly and inserting the small end of one pipe into the large end of the next, and riveting the joint, the ends

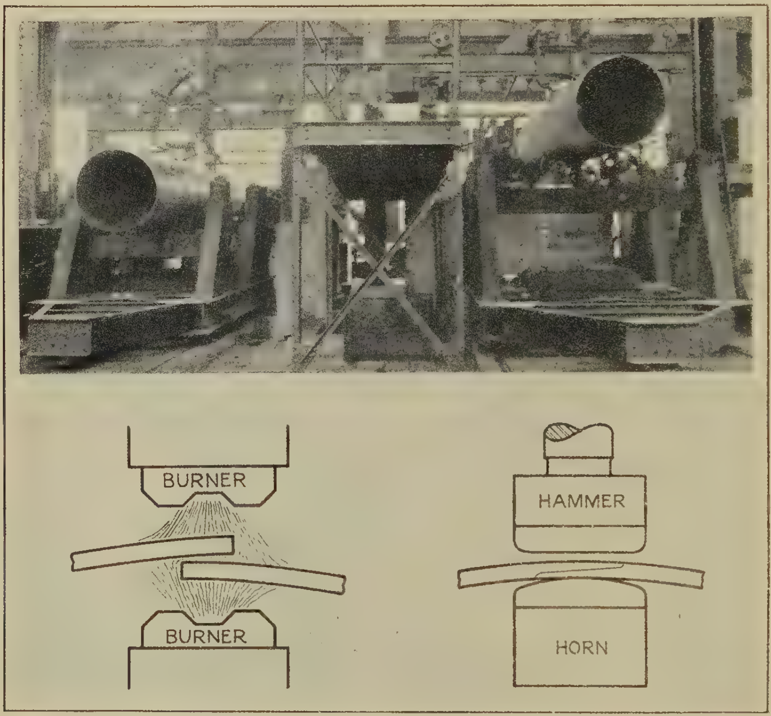


FIG. 8. MAKING HAMMER-WELD PIPE

of the outer portion of each bar being scarfed down under the overlapping plate. Butt-strap joints are also frequently used.

Hammer-weld pipe is made by welding together the two longitudinal edges of one bent plate, or the adjacent longitudinal edges of two or more bent plates, to form the circumferential shell of the pipe. The edges to be welded are lapped, and then heated with gas burners, one above and one below, for a length of 18 inches at a time. The burners are then removed, and before the metal has time to cool,

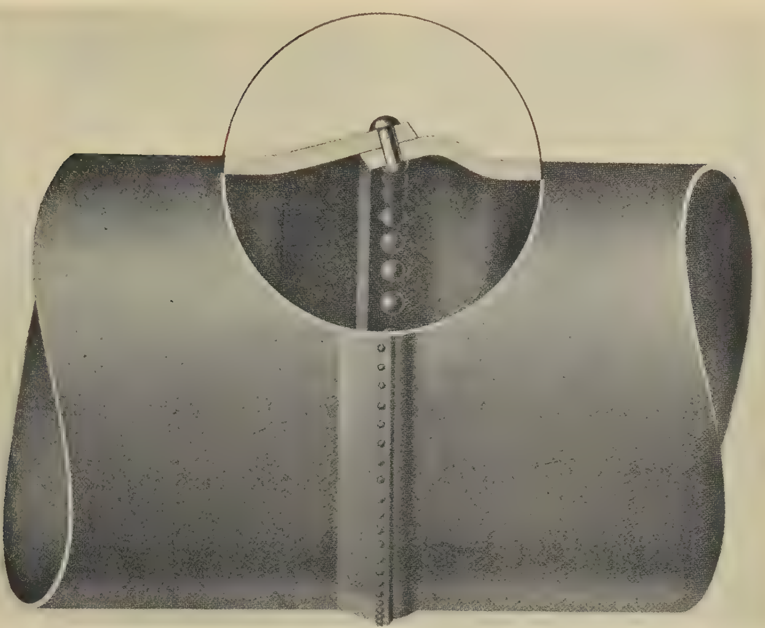
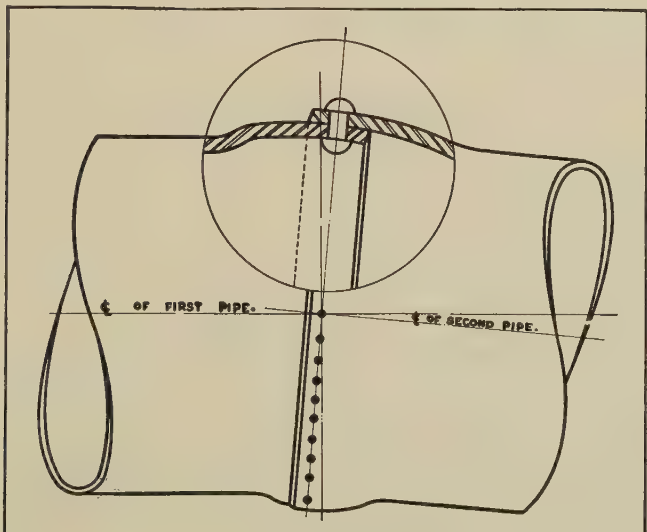


Fig. 9. Tapered Bump Joint



–Spherical Bump Joint.

Fig. 10. Spherical Bump Joint

the edges are welded over a horn below them by blows from a hammer above them. The upper half of figure 8 shows two welding machines at work. The lower half shows the gas burners at the left and the hammer and horn at the right.

Figure 9 shows a single riveted tapered bump joint. Figure 10 shows a spherical bump joint, which may be used for angles up to 5 degrees. The rivet holes in the female end of this joint are drilled in the shop, and after the two pipes have been assembled at the desired angle in the trench, these holes serve as a templet for drilling the holes in the male end.

Other joints that may be used with steel pipe include the Mattheson, Dresser, and other types of sleeve or coupling joints; as well as expansion joints, flanged joints, and bell and spigot joints, each of several different types.

Spiral pipes with edges either riveted or crimped together have been in successful use for many years, but principally in sizes of less than 36 inches and where the conditions permit the use of thin shells. The circumferential joints of these pipes are usually either riveted or flanged.

Concrete

Monolithic reinforced concrete pipe has been built in a number of places, generally in very large sizes and under low heads. Theoretically, the construction of monolithic concrete pipe is continuous; actually, it is intermittent, and usually involves circumferential construction joints at short intervals of from 10 to 20 feet. Where the operation of pouring the invert is separate from that of pouring the arch, there are two continuous construction joints along the entire pipe.

No one who has ever built a reservoir with thin walls needs to be told that it is exceedingly difficult to make a construction joint water tight without inserting some sort of metal diaphragm along it. It is also difficult to tamp monolithic pipes thoroughly and to give them as smooth an inner surface as can be obtained with precast pipe tamped between vertical steel forms. Furthermore, the pipe is rigid and has within itself no provision for expansion, contraction, or settlement.

There are many situations in which monolithic pipe, especially in very large sizes, can compete successfully with precast pipe, but the foregoing facts with regard to monolithic pipe should be considered

by anyone who contemplates its use. If these facts are overlooked, disappointment is likely to result.

There are countless makers of reinforced concrete pipe with rigid joints, but, so far as the author has been able to learn, there is only one company which has manufactured and laid on a large scale precast concrete water pipe having joints that will permit, without material leakage, as great a degree of expansion, contraction or settlement for like diameters, as will the lead joints of standard bell and spigot cast iron pipe. In sizes up to 36-inch this pipe is made by the centrifugal process in a manner similar to that described for centrifugal cast iron pipe, and with somewhat similar results, the material in the

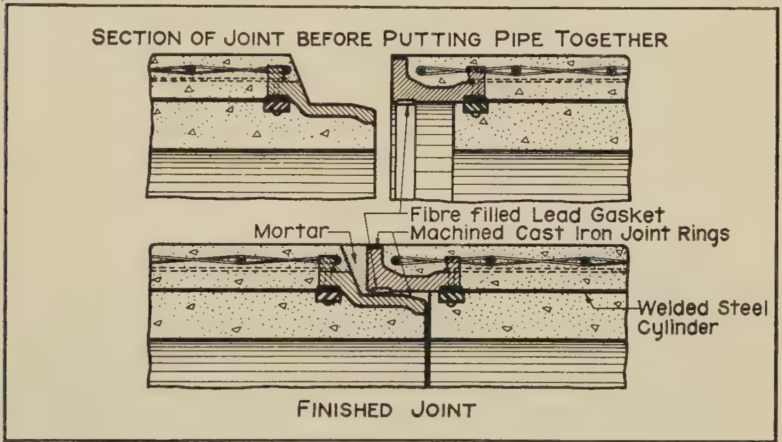


FIG. 11. JOINT OF NORFOLK CYLINDER PIPE

shell of the pipe being much denser and the shell much thinner than in the cast pipe of like diameter and designed for the same heads. From 36 inches up to 108 inches, reinforced concrete pipe is now cast between vertical steel forms. Centrifugal concrete pipe is made for heads up to 200 feet; and the cast concrete pipe with bar and mesh reinforcement and without the steel cylinder, is made for heads up to 150 feet. Under greater heads water would seep through the thin concrete walls, and to prevent this, welded cylinders of thin steel plate are inserted between the forms in which the pipe is cast, thus providing a water tight diaphragm with concrete on both sides. In the design of the pipe this thin steel plate is not counted as part of the reinforcement.

The pipe last described is called "Cylinder Pipe" and was first installed about three years ago for part of the line from Lake Prince to Norfolk, Virginia. Figure 11 is a cross-section of the type of joint used in the Norfolk pipe line just mentioned, and shows the shape of the lead gasket before and after the two pipes are pulled together in the trench. Figure 12 shows the type of joint used in the 60-inch and 54-inch pipe lines now being built for Tulsa, Oklahoma, and in the 54-inch pipe line under construction for Denver. In this joint the lead gasket is inserted as the pipe is laid, and is then driven only partly home by caulking from the inside. After the backfilling is completed and the pipe has had time to settle to its final position, caulkers enter the pipe and drive the gasket solidly home, after which the filler-ring of cement mortar is plastered against the gasket. Any internal water pressure which may reach the gasket tends to tighten the joint instead of blowing it out.

Figure 13 shows part of the pipe making plant for the Tulsa line, with the cages of bar reinforcement in the right center of the picture, and the cages of mesh reinforcement connected to the male and female end rings in the left foreground.

Figure 14 shows the placing of the cages of reinforcement around the inner steel forms.

Figure 15 shows the double gantry crane used for pouring the pipe and for handling the pipe and the forms; the rows of pipes and forms; and the pipe racks for storing and curing the pipe. As soon as each pipe is poured it is covered with a tarpaulin and cured for two days in wet steam at about 100 degrees Fahrenheit. It can then safely be picked up by the gantry and laid on the pipe rack, where it is cured for ten days longer before being loaded on cars for transportation to the trench.

In figure 16 are shown a number of cast iron bases for the steel forms. The pipe with the steel band around its middle is ready to be picked up and laid on the pipe rack.

Wood stave

The staves of wood stave pipe are so milled that their outer and inner surfaces conform to the outer and inner cylindrical surfaces of the pipe. The abutting edges of each stave are radial plane surfaces except that there is a small triangular tongue along one radial edge, and a corresponding small triangular groove along the other edge to receive the tongue of the adjacent stave. The

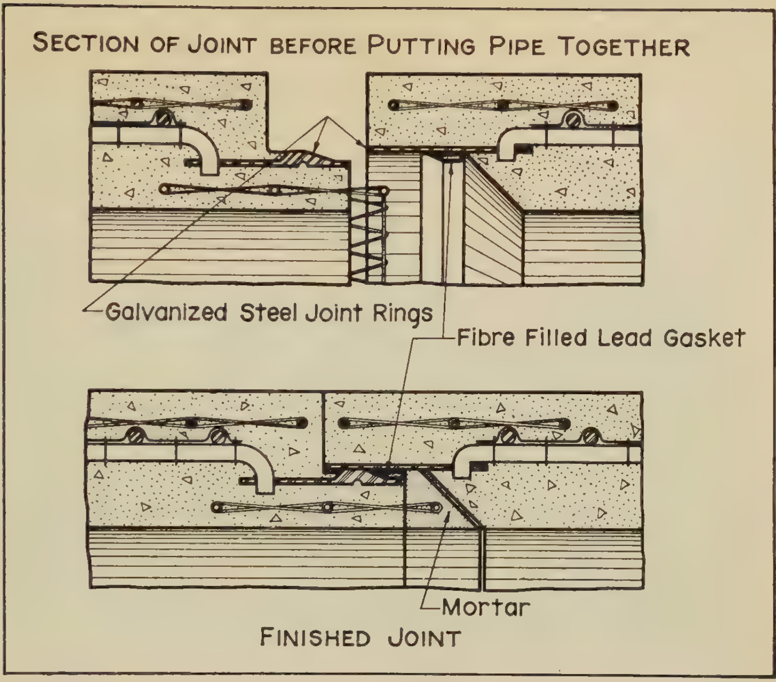


FIG. 12. JOINT OF PIPE FOR TULSA

FIG. 13. PART OF PIPE MAKING PLANT, TULSA

Fig. 14. Placing Reinforcement, Tulsa

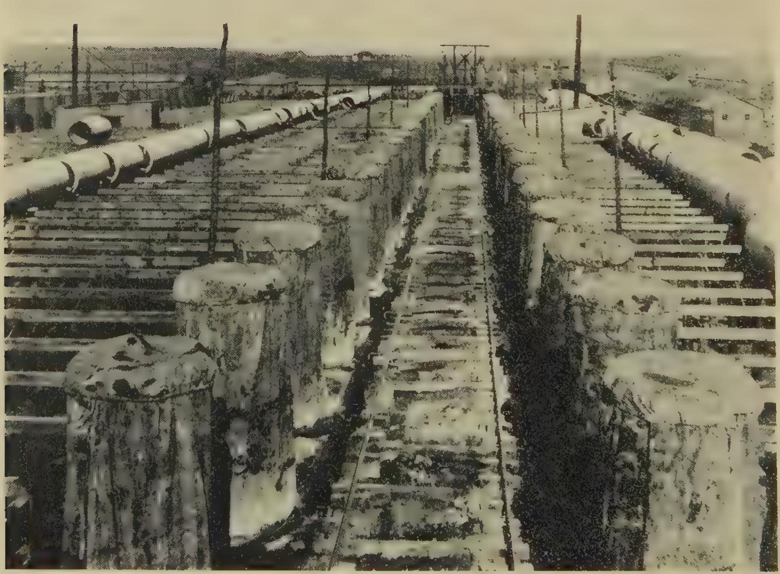


Fig. 15. Forms, Pipe Racks and Crane, Tulsa

Fig. 16. Cast Iron Bases for Forms, Tulsa

Fig. 17. Wood Stave Pipe, Norfolk

makers of pine pipe have two such tongues and grooves in the edges of their staves, which are thicker than the staves used in the Pacific Coast pipé. These tongues and grooves insure a smoother and more truly cylindrical inner surface by preventing any one stave from projecting further down into the pipe than its neighbors on either side of it. The tongue and groove also tend to prevent leakage at the longitudinal joints between staves.

Continuous stave pipe is built up progressively in the trench, the staves, bands, shoes and tongues being shipped unassembled. The staves come in random lengths. They have no tenons, but are cut off square at the ends, the joints between stave ends being made water tight by small steel tongues fitting into saw-kerfs in the abutting ends. The staves are held together by steel bands, the diameter and spacing of which are determined by the diameter of the pipe and by the internal pressures which they are called upon to resist.

A portion of the Norfolk wood stave line is shown in figure 17.

Wood stave pipe when once laid should be kept always full of water under pressure. Unless there can be some reasonable assurance that it will not be frequently subjected to alternations of wetness and dryness, wood stave pipe should not be laid except to meet a temporary emergency. If the staves be allowed to dry out, the pipe is sure to leak, for a time at least, as soon as it is refilled; and if they be subjected to frequent alternations of wetness and dryness, the staves will rot.

To keep the pipe just full of water, but not under pressure, will not be sufficient to protect the staves from decay, as a certain amount of pressure is required to force the water into the staves and saturate them thoroughly; and a permanently saturated condition is the thing which conduces most to the longevity of the staves. For this reason it is desirable not to lay any portion of a wood stave line within less than 30 feet of the hydraulic gradient.

The staves should be thoroughly seasoned and dried, and should be absolutely free from knots and sap wood. In its freedom from knots and sap, as well as in its durability, redwood, in the author's opinion, is superior to fir.

General

If the best results are to be obtained from any of the pipes here discussed, care, intelligence and the knowledge born of experience

should be exercised in installing them in the field. Careful surveys and test borings to determine the best location of the line will undoubtedly always pay for themselves. The final location should only be selected after a thorough study of its effect on the hydraulic gradient of the line, and of the nature of the difficulties encountered,—such as rock excavation, abnormally wet soils, river, creek and railway crossings; and other things which would tend to increase the cost of the work. In some parts of this country soils containing alkali have been known to cause serious and rapid injury to concrete, steel, and cast iron pipes, and to the bands, and even to the staves, of wood stave pipe. The soil of salt marshes will corrode iron and steel rapidly. Where there is any danger of the existence of these conditions, analyses should be made to determine whether the soil contains injurious chemical constituents.

Great care should be taken to provide a firm and uniform foundation for the pipe, no matter what may be its material, as settlement is bad for any pipe. By far the larger part of the breaks which have occurred in cast iron pipe have been due to settlement rather than to internal pressure. All bends should be firmly braced. The materials for backfilling under and around the pipe should be carefully selected, and should be so compacted as to prevent unequal external pressures. These unequal pressures are much less dangerous to cast iron and concrete pipes than to steel and wood stave pipes.

In order to prevent the formation of a vacuum in the pipe, an air valve of ample size should be set at every important summit on the line. This valve should be of a type which will admit air freely and promptly when the internal pressure is removed, and which will remain open and allow air to pass out freely as the pipe is refilled, closing automatically as soon as the pipe beneath it is full of water. The danger of injury to the line as the result of the sudden formation of a vacuum in it would be very much greater in the case of steel or wood stave pipes than in the case of concrete or cast iron pipes. Air pockets at summits will reduce the carrying capacity of any pipe line and will frequently cause objectionable water ram; and air valves properly placed will keep these pockets from forming. In the case of wood stave pipe, the existence of air pockets will be very injurious to the staves, as it will make them alternately wet and dry, thus accelerating their decay.

The installation of gate valves on a large water supply main is a matter which deserves careful consideration. Gate valves are usually inserted for the purpose of isolating one section of the line in order that it may be drained for repairs; but in the author's opinion there are many cases in which no gate valves should be placed in any part of the line except at its upper end. The closing of a gate valve may increase the pressure back of it beyond that for which the pipe is designed; and unless there is an ample air inlet in the pipe immediately beyond the gate valve, the closing of the gate may also cause an injurious vacuum to be formed in the pipe beyond it. Furthermore, large gate valves are very expensive.

In many cases it is wise to install overflow openings of the full capacity of the pipe on at least a few of the more important summits. These overflows should be carried up to the hydraulic gradient, and they should be capable of admitting air rapidly, as well as of providing for the overflow of water. They should be so built as to make it impossible for birds to enter the pipe or for anyone to put any injurious substance into it, and they should contain provision for the insertion of a bulkhead across the pipe. These bulkheads will enable the overflows to be used as test towers for determining by actual measurement the leakage in the portion of the line lying between any two of them.

There will be about ten of these combination overflows, air inlets and test towers on the 28 miles of 60-inch and 24 miles of 54-inch concrete pipe now under construction for the City of Tulsa.

It is also a good plan to provide plenty of manholes in any line which is large enough for a man to enter.

Divided responsibility on any work almost invariably leads to trouble, and it is therefore desirable to have all of the work connected with any pipe line done by one contractor. The makers of cast iron and steel pipe will not contract to do more than furnish their own products, and all of the field work must be done either by the purchaser or by a contractor acting as his agent. In the case of these two pipes this condition is not so objectionable as it has been found to be in the case of concrete and wood stave conduits, where the pipe maker lays his own pipe, and guarantees its perfection. If the transportation, excavation, backfilling and tamping be done by any other party, trouble may be expected. Wherever possible all of this work should be done by the contractor who furnishes the pipe.

FIRST COST

The estimates of first cost herein presented are approximate only, as they are necessarily based on certain assumed conditions which might not obtain in any given case.

They are limited to one type of pipe in each of the four materials, this being done not with the intention of indicating a preference for the types considered, but because the time required for estimates on every available type would be out of all proportion to the value of the estimates.

The precast concrete pipe discussed is patented; but it is believed that there are patents on one or more details, either of design or manufacture, in the case of practically every other pipe considered. In any event, competition between a number of available types could be secured by a properly worded advertisement of the letting.

In each of the estimates deliveries of material are supposed to be f.o.b. cars, with Chicago freight allowed.

Prices of materials are those of January 1, 1924, and common labor is taken at 50 cents an hour. Trenches are assumed to have a clear width 2 feet greater than the outside diameter of the pipe, and to be deep enough to provide 2 feet of cover. In each case the length of the line is assumed to be 25 miles, and the average haul from cars to trench is assumed to be half of this length, or $12\frac{1}{2}$ miles. Where the weight of a single pipe is less than 3 tons, the hauling is assumed to be done by truck. For pipe of greater weight, the cost of constructing and operating a temporary railroad is included in the item of hauling. Each item includes contractor's profit.

Cast iron

Table 1 shows the estimates of first cost of standard bell and spigot cast iron pipe of various diameters and for various heads. In further explanation it may be said that the item of 15 per cent in column 6 is intended to cover all unusual difficulties, such as deep or wet trenches; rock excavation; river, creek and railway crossings; valves, fittings, manholes, air valves and drains; and engineering plans and supervision.

Steel pipe

Table 2 shows the estimated first cost of hammer-weld steel pipe. Column 6 in this table covers the same items as in table 1.

TABLE 1

Cast iron pipe

Costs per linear foot

INSIDE DIAMETER	(1) CAST IRON PIPE F.O.B. CHICAGO	(2) HAULING	(3) TRENCHING AND BACK-FILLING	(4) LEAD YARN AND LAYING	(5) SUM OF COLUMNS 1, 2, 3 AND 4	(6) APPURTENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(7) TOTAL COST COLUMN 5 AND COLUMN 6
50 and 100 foot head (Class A)							
inches							
20	$4.55	$0.50	$0.60	$0.47	$6.12	$0.92	$7.04
24	6.19	0.57	0.70	0.57	8.03	1.20	9.23
30	8.86	0.78	0.88	0.71	11.23	1.68	12.91
36	11.90	1.02	1.06	0.87	14.85	2.23	17.08
42	15.54	1.20	1.28	1.00	19.02	2.85	21.87
48	20.24	1.30	1.53	1.18	24.25	3.64	27.89
54	24.28	1.80	1.76	1.35	29.19	4.38	33.57
60	27.83	2.00	2.02	1.52	33.37	5.01	38.38
72	38.94	2.40	2.61	1.84	45.79	6.87	52.66
150 and 200 foot head (Class B)							
20	4.87	0.56	0.60	0.47	6.50	0.98	7.48
24	6.49	0.66	0.70	0.57	8.42	1.26	9.68
30	9.27	0.87	0.88	0.71	11.73	1.76	13.49
36	12.64	1.15	1.06	0.87	15.72	2.36	18.08
42	16.49	1.25	1.28	1.00	20.02	3.00	23.02
48	20.89	1.60	1.53	1.18	25.20	3.78	28.98
54	25.98	2.00	1.76	1.35	31.09	4.66	35.75
60	30.75	2.30	2.02	1.52	36.59	5.49	42 08
72	43.06	2.80	2.61	1.84	50.31	7.55	57.86
250 foot head (Class C)							
20	5.79	0.60	0.60	0.47	7.46	1.19	8.65
24	7.77	0.76	0.70	0.57	9.80	1.47	11.27
30	11.14	1.04	0.88	0.71	13.77	2.07	15.84
36	15.21	1.30	1.06	0.87	18.44	2.77	21.21
42	19.97	1.40	1.28	1.00	23.65	3.55	27.20
48	25.29	1.95	1.53	1.18	29.95	4.49	34.44
54	31.78	2.15	1.76	1.35	37.04	5.56	42.60
60	37.35	2.50	2.02	1.52	43.39	6.51	49.90
72	53.03	3.30	2.61	1.84	60.78	9.12	69.90

TABLE 2

Steel pipe

Costs per linear foot

INSIDE DIAMETER	THICKNESS	(1) PIPE F.O.B. CHICAGO	(2) HAULING	(3) TRENCHING AND BACK-FILLING	(4) LAYING	(5) SUM OF COLUMNS 1, 2, 3 AND 4	(6) APPURTENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(7) TOTAL COST COLUMN 5 AND COLUMN 6
				50 to 150 foot head				
inches	*inches*							
20	$\frac{1}{4}$	$4.26	$0.20	$0.51	$0.25	$5.22	$0.78	$6.00
24	$\frac{5}{16}$	6.39	0.25	0.59	0.27	7.50	1.12	8.62
30	$\frac{5}{16}$	8.07	0.33	0.74	0.30	9.44	1.42	10.86
36	$\frac{3}{8}$	11.74	0.45	0.94	0.33	13.46	2.02	15.48
42	$\frac{3}{8}$	14.11	0.50	1.17	0.36	16.14	2.42	18.56
48	$\frac{3}{8}$	16.23	0.55	1.37	0.40	18.55	2.78	21.33
54	$\frac{7}{16}$	21.17	0.73	1.58	0.50	23.98	3.60	27.58
60	$\frac{7}{16}$	23.68	0.80	1.83	0.60	26.91	4.04	30.95
72	$\frac{1}{2}$	34.86	1.00	2.34	0.70	38.90	5.84	44.74
				200 foot head				
20	$\frac{1}{4}$	4.26	0.20	0.51	0.25	5.22	0.78	6.00
24	$\frac{5}{16}$	6.39	0.25	0.59	0.27	7.50	1.12	8.62
30	$\frac{5}{16}$	8.07	0.33	0.74	0.30	9.44	1.42	10.86
36	$\frac{3}{8}$	11.74	0.45	0.94	0.33	13.46	2.02	15.48
42	$\frac{3}{8}$	14.11	0.50	1.17	0.36	16.14	2.42	18.56
48	$\frac{7}{16}$	18.82	0.65	1.37	0.40	21.24	3.19	24.43
54	$\frac{7}{16}$	21.17	0.73	1.58	0.50	23.98	3.60	27.58
60	$\frac{1}{2}$	26.81	0.85	1.83	0.60	30.09	4.51	34.60
72	$\frac{1}{2}$	34.86	1.00	2.34	0.70	38.90	5.84	44.74
				250 foot head				
20	$\frac{1}{4}$	4.26	0.20	0.51	0.25	5.22	0.78	6.00
24	$\frac{5}{16}$	6.39	0.25	0.59	0.27	7.50	1.12	8.62
30	$\frac{5}{16}$	8.07	0.33	0.74	0.30	9.44	1.42	10.86
36	$\frac{3}{8}$	11.74	0.45	0.94	0.33	13.46	2.02	15.48
42	$\frac{7}{16}$	16.31	0.55	1.17	0.36	18.39	2.76	21.15
48	$\frac{1}{2}$	21.32	0.75	1.37	0.40	23.84	3.58	27.42
54	$\frac{1}{2}$	24.23	0.80	1.58	0.50	27.11	4.07	31.18
60	$\frac{1}{2}$	26.81	0.85	1.83	0.60	30.09	4.51	34.60
72	$\frac{1}{2}$	34.86	1.00	2.34	0.70	38.90	5.84	44.74

TABLE 3

Concrete pipe

Costs per linear foot

Inside diameter	(1) Pipe and laying	(2) Hauling	(3) Trenching and back-filling	(4) Sum of columns 1, 2 and 3	(5) Appurtenances, unusual difficulties and engineering	(6) Total cost column 4 and column 5
50 foot head						
inches						
20	$3.53	$0.70	$0.58	$4.81	$0.72	$5.53
24	4.70	0.75	0.68	6.13	0.92	7.05
30	6.37	0.85	0.84	8.06	1.21	9.27
36	7.84	1.00	1.01	9.85	1.48	11.33
42	9.70	1.62	1.37	12.69	1.90	14.59
48	11.76	1.90	1.63	15.29	2.29	17.58
54	13.20	2.11	1.83	17.14	2.57	19.71
60	14.70	2.25	2.13	19.08	2.86	21.94
72	19.11	2.80	2.70	24.61	3.69	28.30
100 foot head						
20	3.67	0.70	0.58	4.95	0.74	5.69
24	4.90	0.75	0.68	6.33	0.95	7.28
30	6.87	0.85	0.84	8.56	1.28	9.84
36	8.33	1.00	1.01	10.34	1.55	11.89
42	10.55	1.62	1.37	13.54	2.03	15.57
48	13.23	1.90	1.63	16.76	2.51	19.27
54	15.00	2.11	1.83	18.94	2.84	21.88
60	16.91	2.25	2.13	21.29	3.19	24.48
72	22.05	2.80	2.70	27.55	4.13	31.68
150 foot head						
20	4.17	0.70	0.58	5.45	0.82	6.27
24	5.39	0.75	0.68	6.82	1.02	7.84
30	7.55	0.85	0.84	9.24	1.39	10.63
36	9.31	1.00	1.01	11.32	1.70	13.02
42	12.50	1.62	1.37	15.49	2.32	17.81
48	16.07	1.90	1.63	19.60	2.94	22.54
54	18.10	2.11	1.83	22.04	3.30	25.34
60	20.58	2.25	2.13	24.96	3.74	28.70
72	25.97	2.80	2.70	31.47	4.72	36.19

TABLE 3—*Continued*

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK-FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPURTENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
			200 foot head			
inches						
20	$4.51	$0.70	$0.58	$ 5.79	$0.87	$ 6.66
24	5.83	0.75	0.68	7.26	1.09	8.35
30	8.04	0.85	0.84	9.73	1.46	11.19
36	10.29	1.00	1.01	12.30	1.84	14.14
42	13.20	1.62	1.37	16.19	2.43	18.62
48	16.66	1.90	1.63	20.19	3.03	23.22
54	19.05	2.11	1.83	22.99	3.44	26.43
60	21.81	2.25	2.13	26.19	3.93	30.12
72	27.19	2.80	2.70	32.69	4.90	37.59
			250 foot head			
20	5.50	0.80	0.68	6.98	1.05	8.03
24	7.00	0.88	0.77	8.65	1.30	9.95
30	9.75	1.00	0.95	11.70	1.76	13.46
36	12.49	1.30	1.13	14.92	2.24	17.16
42	14.90	1.62	1.37	17.89	2.68	20.57
48	17.64	1.90	1.63	21.17	3.18	24.35
54	20.15	2.11	1.83	24.09	3.61	27.70
60	23.03	2.25	2.13	27.41	4.11	31.52
72	28.42	2.80	2.70	33.92	5.09	39.01

The author is aware that the thicknesses of shell which he has assumed are considerably greater than would be called for by the stresses due to internal pressure. The extra metal is included in order to allow something for corrosion and to provide a stiffer pipe. Other engineers might prefer to use thinner shells with a corresponding decrease in first cost. Close competition with hammer-weld pipe might be expected from lock-bar pipe, riveted pipe, and, in small sizes, from spiral pipe.

Concrete

Table 3 gives estimates of the cost of lock joint reinforced concrete pipe. Column 1 contains quotations from the makers for the pipe delivered f.o.b. cars Chicago, plus the laying of the pipe

TABLE 4

Continuous stave redwood pipe

Costs per linear foot

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK-FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPUR-TENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
			50 foot head			
inches						
20	$2.34	$0.07	$0.60	$3.01	$0.45	$3.46
24	2.80	0.09	0.70	3.59	0.54	4.13
30	3.45	0.11	0.88	4.44	0.67	5.11
36	4.12	0.14	1.06	5.32	0.80	6.12
42	4.96	0.16	1.28	6.40	0.96	7.36
48	5.70	0.19	1.53	7.42	1.11	8.53
54	8.50	0.30	1.76	10.56	1.58	12.14
60	9.61	0.34	2.02	11.97	1.80	13.77
72	13.55	0.48	2.61	16.64	2.50	19.14
			100 foot head			
20	2.76	0.08	0.60	3.44	0.52	3.96
24	3.31	0.10	0.70	4.11	0.62	4.73
30	4.16	0.14	0.88	5.18	0.78	5.96
36	5.09	0.17	1.06	6.32	0.95	7.27
42	6.25	0.21	1.28	7.74	1.16	8.90
48	7.36	0.26	1.53	9.15	1.37	10.52
54	10.75	0.38	1.76	12.89	1.93	14.82
60	12.34	0.44	2.02	14.80	2.22	17.02
72	17.70	0.63	2.61	20.94	3.14	24.08
			150 foot head			
20	3.20	0.10	0.60	3.90	0.58	4.48
24	3.86	0.12	0.70	4.68	0.70	5.38
30	4.91	0.16	0.88	5.95	0.89	6.84
36	6.10	0.21	1.06	7.37	1.10	8.47
42	7.56	0.26	1.28	9.10	1.36	10.46
48	9.09	0.32	1.53	10.94	1.64	12.58
54	13.19	0.47	1.76	15.42	2.31	17.73
60	15.19	0.55	2.02	17.76	2.66	20.42
72	21.85	0.78	2.61	25.24	3.79	29.03

TABLE 4—*Continued*

INSIDE DIAMETER	(1) PIPE AND LAYING	(2) HAULING	(3) TRENCHING AND BACK-FILLING	(4) SUM OF COLUMNS 1, 2 AND 3	(5) APPUR-TENANCES, UNUSUAL DIFFICULTIES AND ENGINEERING	(6) TOTAL COST COLUMN 4 AND COLUMN 5
			200 foot head			
inches						
20	3.66	0.11	0.60	4.37	0.66	5.03
24	4.40	0.14	0.70	5.24	0.79	6.03
30	5.69	0.19	0.88	6.76	1.01	7.77
36	7.16	0.25	1.06	8.47	1.27	9.74
42	8.89	0.31	1.28	10.48	1.57	12.05
48	11.90	0.43	1.53	13.86	2.08	15.94
54	15.60	0.56	1.76	17.92	2.69	20.61
60	19.56	0.70	2.02	22.28	3.34	25.62
72	28.75	1.07	2.61	32.43	4.86	37.29
			250 foot head			
20	4.15	0.12	0.60	4.87	0.73	5.60
24	4.90	0.15	0.70	5.75	0.86	6.61
30	7.36	0.25	0.88	8.49	1.27	9.76
36	8.97	0.32	1.06	10.35	1.55	11.90
42	11.04	0.40	1.28	12.72	1.91	14.63
48	13.60	0.49	1.53	15.62	2.34	17.96
54	19.62	0.69	1.76	22.07	3.31	25.38
60	22.46	0.80	2.02	25.28	3.79	29.07
72	32.79	1.22	2.61	36.62	5.49	42.11

in the trench. The figures in table 3 for diameters of from 20-inch to 36-inch, inclusive, and for heads up to and including 200 feet, are for centrifugal pipe. From 42-inch to 72-inch, inclusive, and for heads up to and including 100 feet, the figures are for precast concrete pipe without any steel cylinder. All other figures given are for cylinder pipe, but it should be noted that the figures for pipes less than 36-inch in diameter, and for 250 foot head, have been interpolated by the author, no quotations having been received for these pipes. Competition in concrete pipe would come from monolithic concrete pipe, for which the engineer would have to prepare his own designs and make his own estimates; and probably also from some of the makers of other types of precast concrete pipe. The figures in column 5 include 15 per cent for the same items already enumerated for column 6 in tables 1 and 2.

Wood stave

The quotations presented in column 1 of table 4 are from the Redwood Manufacturers Company, and include the delivery of all pipe materials with Chicago freight allowed, and the assembling and laying of the pipe in the trench. All prices are for continuous stave pipe, although machine banded pipe would be available in diameters of from 2-inch up to 24-inch. Column 5 in table 4 covers items similar to those covered in column 5 of table 3, and in column 6 of tables 1 and 2.

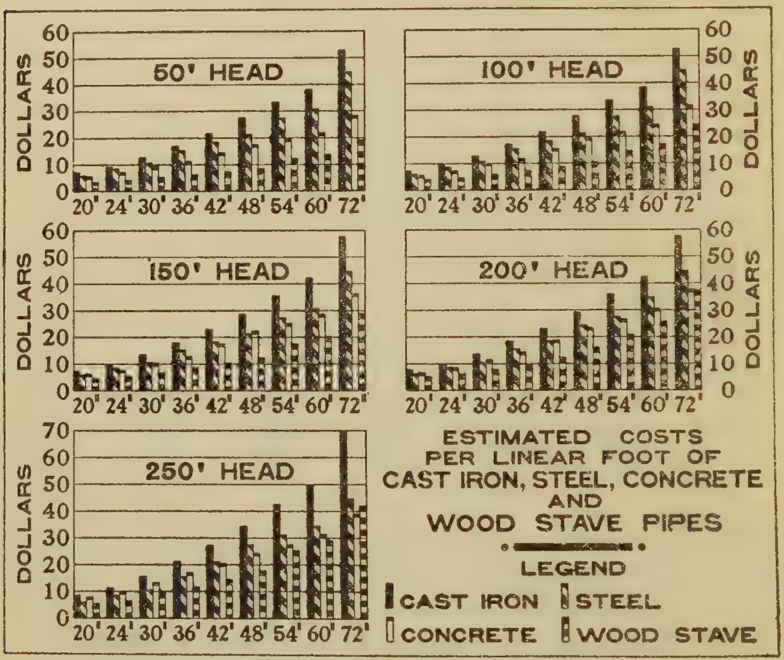


Fig. 18. Diagram Showing Summary of Pipe Costs

Competitive bids for wood stave pipe built of redwood or fir might be received from the Pacific Tank & Pipe Company, the Continental Pipe Company, and the American Wood Pipe Company, all of the Pacific Coast; and on pipe with white pine staves from the Michigan Pipe Company of Bay City, Michigan, and A. Wyckoff and Son Company of Elmira, New York, the latter firm being apparently more interested in machine banded pipe than in continuous stave pipe.

A summary of the respective costs per linear foot, estimated as above explained, is presented in table 5, and the diagrams in figure 18 were prepared to illustrate this summary.

TABLE 5

Summary of costs per linear foot

SIZE	50 FOOT HEAD				100 FOOT HEAD			
	Cast iron	Steel	Concrete	Wood stave	Cast iron	Steel	Concrete	Wood stave
inches								
20	$7.04	$6.00	$5.53	$3.46	$7.04	$6.00	$5.69	$3.96
24	9.23	8.62	7.05	4.13	9.23	8.62	7.28	4.73
30	12.91	10.86	9.27	5.11	12.91	10.86	9.84	5.96
36	17.08	15.48	11.33	6.12	17.08	15.48	11.89	7.27
42	21.87	18.56	14.59	7.36	21.87	18.56	15.57	8.90
48	27.89	21.33	17.58	8.53	27.89	21.33	19.27	10.52
54	33.57	27.58	19.71	12.14	33.57	27.58	21.88	14.82
60	38.38	30.95	21.94	13.77	38.38	30.95	24.48	17.02
72	52.66	44.74	28.30	19.14	52.66	44.74	31.68	24.08
	150 FOOT HEAD				200 FOOT HEAD			
20	$7.48	$6.00	$6.27	$4.48	$7.48	$6.00	$6.66	$5.03
24	9.68	8.62	7.84	5.38	9.68	8.62	8.35	6.03
30	13.49	10.86	10.63	6.84	13.49	10.86	11.19	7.77
36	18.08	15.48	13.02	8.47	18.08	15.48	14.14	9.74
42	23.02	18.56	17.81	10.46	23.02	18.56	18.62	12.05
48	28.98	21.33	22.54	12.58	28.98	24.43	23.22	15.94
54	35.75	27.58	25.34	17.73	35.75	27.58	26.43	20.61
60	42.08	30.95	28.70	20.42	42.08	34.60	30.12	25.62
72	57.86	44.74	36.19	29.03	57.86	44.74	37.59	37.29
	250 FOOT HEAD							
20	$8.65	$6.00	$8.03	$5.60				
24	11.27	8.62	9.95	6.61				
30	15.84	10.86	13.46	9.76				
36	21.21	15.48	17.16	11.90				
42	27.20	21.15	20.57	14.63				
48	34.44	27.42	24.35	17.96				
54	42.60	31.18	27.70	25.38				
60	49.90	34.60	31.52	29.07				
72	69.90	44.74	39.01	42.11				

PHYSICAL COMPARISON

It will next be in order to discuss the physical advantages or disadvantages of the four types of pipe whose construction costs have

been estimated, and to endeavor to put values on these advantages or disadvantages, to the end that when proper allowances shall have been made for these values, the pipes may be compared strictly on a dollar-and-cent basis.

In what follows no attempt will be made to compute the values of these advantages for each size of pipe and for each different head, but one method of computing these values and allowing for them will be illustrated by an example in which certain conditions will be assumed to exist. The engineer charged with the design of any supply line can substitute for the conditions assumed in the example cited, the actual conditions in the case in which he is interested, and can in that way arrive at conclusions which will fit his case.

The most important things to be considered in comparing the four different types of pipe are their carrying capacity, their leakage and their durability.

Carrying capacity

Unfortunately there is a dearth of data with regard to the capacities of some of the pipe under consideration: and there is a possibility of wide variation in the capacities even of lines built of the same material. The excellent tables of Messrs. Williams and Hazen are almost universally accepted for cast iron and steel pipe. These tables, however, wisely recognize the fact that the interior surfaces of cast iron and steel pipe are subject to corrosion and tuberculation, and that the pipes decrease in capacity with age. Cast iron pipe of large size when first laid may be assumed to have a capacity corresponding to a value of from 130 to 140 for the coefficient C in the Hazen-Williams formula. The coefficient C for cast iron pipes conveying swamp water has been known to decrease in value to 70 in a period of six or seven years.

For mains 36-inch and larger, the Hazen-Williams tables give a value of 100 for the coefficient C after the pipe has been in service for twenty years, and for the purposes of this paper this value will be assumed for cast iron pipe. It would probably also be fair to assume similar values for lock-bar and hammer-weld pipe. Riveted steel pipe would probably have 10 or 15 per cent less capacity than hammer-weld or lock-bar pipe.

The best available tests of reinforced concrete and wood stave pipe are those made by Mr. F. C. Scobey and contained in Bulletins 852 and 376 of the United States Department of Agriculture. Mr.

Scobey gives C in the Hazen-Williams formula a value of 140 for reinforced concrete pipe in which the concrete is well spaded against oiled steel forms. For wood stave pipe C is given as about 125.

So far as is known, the inner surfaces of concrete and wood stave pipes are usually not injuriously affected except to the extent of the formation of a very thin layer of slime, but some slight allowance should be made for this slime as well as for sediment that might be deposited in the pipe. With the best type of modern reinforced concrete pipe made over steel forms, it is believed that it would be fair to assume $C = 140$ for the pipe when first laid, and $C = 130$ for the purpose of comparison with the other pipes herein considered. A similar line of reasoning would lead to the assumption of $C = 115$ for the wood stave pipe.

Leakage

Engineers have estimated the leakage in cast iron pipe at all the way from 100 to 500 gallons per twenty-four hours per inch of diameter per mile of pipe. In the writer's opinion no well laid cast iron main ought to leak more than 100 gallons per inch mile.

Steel pipe ought to be about as tight as cast iron. The reinforced concrete pipe line in Norfolk, some of which was cylinder pipe, leaked under official test 83.6 gallons per inch mile, and 5 miles of 54-inch reinforced concrete pipe, installed in 1921 for Denver, showed a test leakage of 90 gallons per inch mile. The writer has tested two wood stave pipe lines, each of which showed a leakage approximating 1000 gallons per inch mile. One of these lines was very badly laid, however, and was far from being the best type of pipe. In the other line most of the leakage apparently came from cast iron fittings which had not been sufficiently braced.

Unofficial tests of the wood stave pipe laid at Norfolk showed that its leakage, which started considerably above 1000 gallons per inch mile, had been reduced to about 300 gallons within a few months, part of the reduction being due to repairs, and part to the swelling of the staves and the silting up of the joints between the ends of the staves.

For the purpose of this comparison, the leakage of the cast iron, steel and reinforced concrete pipes will be assumed at 100 gallons per inch mile each, and that of the wood stave pipe at 350 gallons per inch mile.

Durability

Volumes might be written on this subject alone, but the life of any pipe is affected to so great an extent by conditions which vary greatly that no one could make even an approximate prediction as to the life of a pipe without a most intimate knowledge of the conditions by which it will be surrounded. Even with this intimate knowledge, no one would be justified in claiming to be able to predict its life within 15 per cent. One might, however, be justified in assuming, for purposes of comparison, certain figures for the longevity of the several pipes, with the understanding that these figures are to be considered as relative only and that they are not put forth as representing the actual respective lives of the pipes considered.

The life of the pipe may be terminated, in the case of cast iron and steel, by the corrosion of the metal; in the case of concrete, by the chemical disintegration of the concrete, combined with the corrosion of the steel; and in the case of the wood stave pipe, by the corrosion of the bands or by the rotting of the staves. The life of any of these pipes may also be terminated by the fact that it has become obsolescent or has reached the limit of its useful term of service.

So far as corrosion is concerned, cast iron pipe, unless affected by electrolysis or unless laid in salt marshes or in soil containing a very high percentage of alkali, or unless conveying water of a very injurious character, will last so long that engineers usually assume its life at one hundred years, on the theory that by that time the pipe may have been disposed of by obsolescence or in some other manner, and that by that time also all persons now living will be dead, and it will not matter very much to any one now interested in the problem how much longer the pipe will last.

Opinions differ as to whether steel is corroded more rapidly than cast iron, although the majority of people would give cast iron somewhat greater durability. In the author's opinion, steel pipe of fair thickness laid in good soil, and conveying ordinarily good water, might be in fair condition so far as strength is concerned, at the end of one hundred years; but if the life of the thicker cast iron be taken at one hundred years it would seem fair, for the purposes of comparison only, to put the life of steel pipe at from forty to eighty years, according to the thickness of its shell.

Concrete pipe has not been in use nearly as long as either cast iron or steel pipe, but concrete is generally recognized as a very durable material, and the steel which gives the pipe its strength is imbedded in and protected by the concrete. Figure 19 shows samples of cast iron and of cement lined steel pipe, all of which were cut from water mains in the City of Norfolk, and all of which had been laid in similar soils and under similar conditions for more than 20 years prior to the time when they were removed from the ground. The outside of the cast iron pipe showed little or no corrosion. Its interior surface, however, had been very seriously corroded by the organic acids in the swamp water conveyed by the

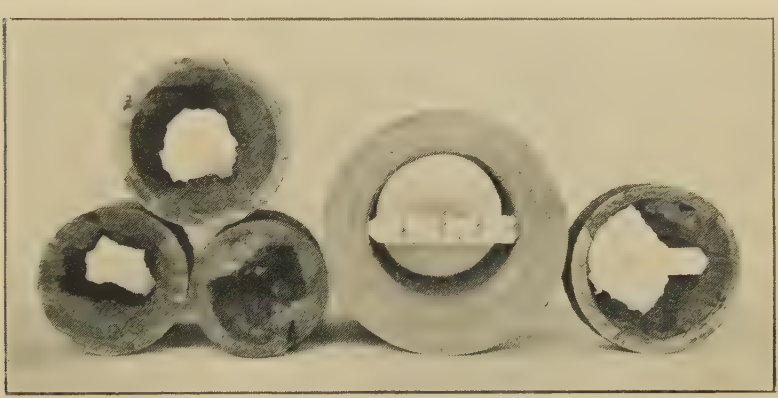


FIG. 19. CAST IRON AND CEMENT LINED PIPE, NORFOLK

pipes. In places this corrosion extended half way from the inner to the outer surface of the pipe, and the metal dissolved by these acids was redeposited in the tubercles shown in the picture.

The concrete pipe shown consisted of an inner lining of one-half-inch of cement mortar, a thin riveted diaphragm of No. 20 gauge steel, then a thickness of $\frac{5}{8}$ inch of cement mortar, and finally an outer shell of No. 28 gauge steel.

The outer steel shell showed some corrosion, but the 20-gauge steel diaphragm between the two layers of cement mortar was absolutely as good as the day the pipe was built, and showed no corrosion of any kind, notwithstanding the fact that when the cement was broken away from it there were drops of moisture on the surface of the thin steel plate.

The theory advanced for the surprisingly good condition of this steel diaphragm was that the presence of the protecting layer of concrete prevented any interchange of the water which first seeped through the mortar to the steel, and consequently any renewal of the dissolving reagents contained in it, and that the acidity of this water was probably neutralized in the first instance by passing through the concrete.

A few decades ago cement lined iron pipe was used quite often, especially in New England, and almost every engineer who has examined this pipe after it had been in the ground for some years has remarked on the excellent state of preservation of the wrought iron or steel diaphragm imbedded in the concrete.

No one knows how long reinforced concrete pipe will last, but if the life of cast iron pipe be assumed at one hundred, and that of steel at from forty to eighty years, it would probably be fair, for the purposes of this comparison, to put the life of concrete pipe at seventy years.

It has sometimes been said that the life of a wood stave pipe is the life of its bands, but this is often far from being the case. If, as already stated, the staves are not kept thoroughly saturated at all times they will decay, no matter whether they are redwood, fir or pine. Furthermore, in certain soils the life of the staves appears to be much shorter than in others. In some of Denver's wood stave conduits the staves have lasted only a few years in certain parts of the line, but are in good condition today, after many years of service, in other parts of the same line. There are, however, many wood stave lines now in existence that are giving first-class service after 25 or 30 years of life, and that will almost certainly continue to give service for many years to come.

The life of the steel bands on wood stave pipe depends on their thickness and on the nature of the soil in which they are buried. In the writer's opinion a continuous stave redwood pipe, if kept full of water under pressure, and laid in ordinarily good soil, may fairly be assumed, for the purposes of comparison, to have a life of forty years.

To sum up, the respective lives of the cast iron, steel, reinforced concrete and wood stave pipes herein considered will be assumed in this paper, and solely for the purposes of the comparison which follows, at 100, 70, 70 and 40 years.

FINANCIAL COMPARISON

It will next be in order to illustrate by an example one method by which allowances, reduced to dollars and cents, can be made for the respective capacities, leakages and durabilities of the four pipes considered.

Some of those allowances will be related to capital charges involving, in some instances, the cost of the entire project, and in others, the cost of portions of the project; and some of them will be related to operating expenses only.

Let us assume that the length of our conduit will be 25 miles, or 132,000 feet; that its diameter will be 54 inches; and that it must be capable of delivering 50 million gallons per 24 hours at its lower end. With $C = 100$ for cast iron and steel pipe, the friction loss for each of these two pipes would be 256 feet; for the concrete pipe, with $C = 130$, the friction loss would be 157 feet; and for the wood stave pipe, with $C = 115$, the friction loss would be 199 feet. In computing the above friction losses, allowance has been made for the small friction loss caused by the water which would leak from each pipe on the way down.

It is next assumed that, if the line be either cast iron or steel, the average head on it would be 150 feet; if concrete, 100 feet; and if wood stave, 122 feet. The difference between these heads for any two pipes is equal to half the difference between the friction losses for the same two pipes.

It is assumed that there will be a dam to form an impounding reservoir at the upper end of the line, and a steam pumping station taking water from the reservoir and forcing it through the pipe. The cost of the dam and pumping station building and immediate piping connections is assumed at $1,800,000 in the case of each of the four pipe lines; and the cost of the pumps and boilers required is roughly estimated at $275,000 for either the cast iron or steel pipe, $200,000 for the concrete pipe and $235,000 for the wood stave pipe, the differences in the cost of the pumping equipment being due entirely to the differences in the pumping heads.

If the average head on the cast iron, steel and wood stave pipes were 100 feet, as in the case of the concrete pipe, it will be seen from table 5 that the first cost of the cast iron pipe would be $33.57, of the steel pipe $27.58, of the concrete pipe $21.88, and of the

wood stave pipe $14.82. But the differences in average head increase the cost of cast iron pipe by $2.18, bringing it up to $35.75, while the cost of the steel pipe is not increased, as the thickness assumed for 100 foot head is sufficient for 150 foot head. The cost of the concrete pipe remains at $21.83, which corresponds to a head of 100 feet. The cost of the wood stave pipe, which is designed for an average head of 122 feet, is found by interpolation to be $16.10, showing an increase of $1.28.

The total actual investment in each case, including an allowance of 50 cents per linear foot for right-of-way, may now be summarized as follows:

	CAST IRON	STEEL	CONCRETE	WOOD STAVE
Dam, pumping station, piping connections and real estate	$1,800,000	$1,800,000	$1,800,000	$1,800,000
Pumping equipment	275,000	275,000	200,000	235,000
Pipe line	4,719,000	3,640,560	2,888,160	2,125,200
Right-of-way	66,000	66,000	66,000	66,000
Total	$6,860,000	$5,781,560	$4,954,160	$4,226,200

The above summary states the estimated actual cost of the several pipe lines, but it will be noted that the pumping equipment required in the case of the cast iron and steel pipes costs $75,000 more than that required for the concrete pipe, and that the pumping equipment for the wood stave pipe costs $35,000 more than that for the concrete pipe. To allow for these differences, we should have to charge the cast iron and steel pipe each with an added cost of 57 cents per linear foot, and the wood stave pipe with an added cost of 27 cents per linear foot, in order to compare them with concrete pipe, on the basis of cost of pumping equipment.

The operating expense for labor would be the same in all four cases; but assuming an average pumpage of 30 million gallons per day, the annual fuel cost at $5.00 per ton for coal is estimated at $46,166 per year for cast iron or for steel; $28,313 for concrete, and $35,887 for wood stave. The difference between the fuel cost for either the cast iron or steel pipes and for the concrete pipe would be $17,853, which amount capitalized at 6 per cent would produce $297,550. Similarly, the difference between the fuel costs for the wood stave pipe and for concrete pipe would be $7,574 which,

capitalized at 6 per cent, would be $126,233. We should charge therefore the cast iron and steel pipes with $297,550 each, and the wood stave pipe with $126,233, in order to allow for the greater carrying capacity of the concrete pipe. These charges would amount to $2.25 per linear foot each in the case of the cast iron and steel pipes, and to $0.96 per linear foot in the case of the wood stave pipe.

We have assumed that the cast iron, steel and concrete pipes would each leak at the rate of 100 gallons in 24 hours per inch of diameter per mile of pipe, and that the leakage in the wood stave line would be 350 gallons per inch mile, so that the wood stave pipe should be charged with the value of 250 gallons per inch mile, in order to put it on the same footing with regard to leakage as the other three pipes. Two hundred and fifty gallons per inch mile would amount to 337,500 gallons per day, which is six hundred and seventy-five one-thousandths of one per cent of the total net capacity of the line.

The cost of the entire project, assuming that wood stave pipe be used, would be $4,226,200, and applying the percentage just found, we have $28,527 as the capital charge against the wood stave pipe, on account of its greater leakage. This corresponds to 22 cents per linear foot.

We must next charge the wood stave line with the capitalized cost of pumping 337,500 gallons of water which would never reach the lower end of the pipe line. Estimating the cost of pumping at three-quarters of a cent per 1000 gallons, the annual cost of pumping 337,500 gallons per day would be $924, which, capitalized at 6 per cent, would equal $15,400, which is equivalent to 12 cents per linear foot.

We must next allow for the respective durabilities of the four pipes. The actual costs per linear foot of the four pipes would, as already stated, be $35.75 for cast iron, $27.58 for steel, $21.88 for concrete, and $16.10 for wood stave.

Having assumed the life of cast iron at one hundred years, and that of steel and concrete each at seventy years, it would be necessary to charge each of the two last named pipes with three-sevenths of a renewal, seventy years from date, to put it on a comparable basis with cast iron.

The present worth of three-sevenths of $27.58, payable seventy years hence, is $0.76, which must be added to the cost of the steel pipe in order to allow for the greater durability of cast iron pipe.

The present worth of three-sevenths of $21.88, payable seventy years hence, is $0.60, and this sum should, for the same reason, be charged against the concrete pipe.

The life of wood stave pipe has been assumed at forty years, and this pipe would require one renewal forty years from now, and one-half of a renewal eighty years from now. The present worth of $16.10, payable forty years hence, is $3.35; and the present worth of one-half of $16.10, payable eighty years hence, is $0.35; and these two amounts must be charged against wood stave pipe to put it on a comparable basis with cast iron as to durability.

TABLE 6

Financial summary

Costs per linear foot

	CAST IRON	STEEL	CONCRETE	WOOD STAVE
Actual first cost	$35.75	$27.58	$21.88	$16.10
Capacity allowances for cost of pumping equipment	0.57	0.57	0.00	0.27
Capacity allowances for cost of pumping	2.25	2.25	0.00	0.96
Leakage allowances, based on total investment	0.00	0.00	0.00	0.22
Leakage allowances, based on cost of pumping the leakage	0.00	0.00	0.00	0.12
Allowance for durability	0.00	0.76	0.60	3.70
Total equivalated costs	$38.57	$31.16	$22.48	$21.37

In table 6 all of the foregoing allowances are set forth under the respective actual costs per linear foot, in order to arrive at the respective costs, corrected for the final comparison.

There are other minor points in which the four pipes differ. For example, wood stave pipe, while elastic enough to withstand a good deal of bending without serious injury, is more fragile than any of the other pipes, is easily collapsed by external pressures, and would probably require somewhat more expense for maintenance throughout its actual life. Most of this expense would be for the renewal of staves and bands. Wood stave pipe, if it is to have a long life, should also be kept full of water under pressure, and it may not always be convenient, or even possible, to do this.

Steel pipe resembles wood stave pipe to some extent in its flexibility and in its tendency to collapse, and is somewhat less able to withstand contractions due to temperature. Most of its maintenance costs would probably be for repairing the pits which might be caused by external or internal corrosion. Recent developments in the art of welding would simplify and cheapen these repairs.

Experience with the modern types of concrete pipe herein discussed has not been long enough to justify any definite statements with regard to the nature of the repairs which might be required. Leakage or even fracture might be caused by extreme deflection due to settlement, but the danger of this would appear to be very remote if the pipe were carefully laid in the beginning, and this would be especially true of concrete pipe of the type in which the joint is caulked from the inside after the trench has been tamped and backfilled and the pipe has settled firmly on its bed.

Cast iron pipe, like the concrete pipe, might leak or break as a result of settlement, and, in fact, a very large percentage of all of the fractures of cast iron pipe come from this cause. These fractures are, however, rare, and cast iron pipe, generally speaking, is easy and inexpensive to maintain. It would probably be necessary to drive up the lead in a few joints occasionally.

Most of the points just referred to are, of course, of small significance as compared with the differences in capacity, leakage and durability for which allowances have been made in the foregoing comparisons and estimates. The author would like to emphasize the statement that all of these comparisons and estimates should be considered solely in the light of the premises and assumptions on which they are based.

DISCUSSION

President Fuller:[3] This paper by Colonel Maury is, I think, a very substantial contribution to the knowledge which we all want in respect to waterworks practice, and the Association is to be congratulated on having such a splendid paper. Colonel Maury has asked me to say a few words based on my own experience, and I believe I should call attention perhaps first to the thought uppermost in my mind, and that is that there is a question of local suitability and reliability which cannot be expressed very adequately in the number of cents or dollars per lineal foot.

[3] Consulting Engineer, New York, N. Y.

It happens that we have had, in connection with our own work, a good deal of experience that has brought us in contact with almost all the different kinds of material for pipe lines. For instance we are now putting in, in Virginia, at Charlottesville and at Staunton, two long lines of mains, in order to bring gravity supplies down to those communities of about 12,000 population each. One of these mains is, I think, an 18-inch line and one a 16-inch. Each of those small cities is spending 600,000 or 700,000 dollars, a lot of money; and we thought there could be no argument there against putting in cast-iron lines. Incidentally, we are having a somewhat unusual experience in regard to our Staunton project, in that the water is to be taken from the forest reserves in the Blue Ridge Mountains in Virginia, and we have run into an injunction seeking to restrain the United States Secretary of Agriculture from giving us a permit, the injunction suit being brought by riparian owners farther down the stream. They have taken testimony, and what the decision will be I do not know.

There were two occasions, one in 1912 and one in 1916, when I went personally with great care over the wood-stave pipe line which had been installed by the city of Lynchburg for its gravity water supply. I was impressed rather favorably with the suitability of the wood-stave pipe line as a result of the experiences which that city had had; and did not recommend any duplication of that wood-stave pipe line other than at the James River crossing and a number of creek crossings where they did have some leaks at intervals and where it was pretty important to be able to correct those leakages more promptly than was at all times possible on account of the inaccessability of the lines at those stream crossings.

At Memphis we are on a cast-iron basis completely. At the new well water supply and new filter plant and pumping station, we have been having water going through for six or seven weeks and we have had there some rather unusual experiences with broken castings. I think that right now the new pumping station is down because we had a break in a 36-inch cast-iron elbow, due to unequal thicknesses of metal, and it made an unfortunate break. Of course, all such things come out in the testing process.

At Kansas City we have figured on a pressure tunnel for taking the water into the city from the new basins; I think it is an 84-inch pressure tunnel. In this case, as in many other projects like our

Philadelphia project, which I am now figuring on as a member of the Water Supply Commission there, when you get up to those very large capacities there is no question but that you have to use concrete structures. I want also to say a word in regard to the 48-inch line which was installed some 4 years ago at Kansas City, the first project that I looked into there. This line was for the purpose of getting water from Quindaro down to the city; and lockjoint concrete pipe, with the particular type of joint used in Tulsa, was put in. I think that line has been in service now for three winters, and so far as I know there has never been one single item of trouble in regard to leakage in that Kansas City line, and this particular joint has been very satisfactory.

These different arrangements all have to be viewed in the light of suitability and reliability. It is not easy to generalize. I want to thank Colonel Maury for his very instructive paper.

Mr. N. S. Hill, Jr.:[4] I think the best thing Colonel Maury has done for us in this paper is to formulate the elements which ought to be considered in making a selection of the material to be used in long supply lines. It brings to mind how complicated the problem is, and I think Mr. Fuller's remarks should be supplemented and strengthened by adding that no figures of cost can reasonably govern in the matter of the selection of material for long supply lines, as each problem is an individual one. As Colonel Maury has pointed out, there are so many elements which must be considered—pressures, the character of the soil, the cost of materials in different localities, the quality of the water, and various other matters, each one which must be weighed on its own merits. The materials used and the type of line installed must be of a character to suit the particular conditions.

I think we are fortunate in having Colonel Maury's paper, for it leads us away from the old idea that there is only one material to use in pipe line construction. I believe water works men generally think solely in terms of cast iron. When cast iron cost from $22 to $28 a ton over a large section of the country, and its durability and dependability are taken into consideration, it was a pretty hard material to beat. Cast iron has now reached such prices, however, that it is a question of serious consideration whether

[4] Consulting Engineer, New York, N. Y.

or not it is always profitable to use it for long supply lines, or whether we will not be forced to adopt steel or concrete, or other means in order to hold the cost of such construction within reasonable limits.

The question of carrying capacities as pointed out by Colonel Maury I think is very important in long pipe lines. Unquestionably if we can get such conduits of a material which will not deteriorate so as to reduce the carrying capacity we are going ahead in the construction of these pipe lines. I am not at all certain in my own mind that the day is not coming wh n the present practice of lining service connections with some non-corrodible material will be followed in large cast iron pipe lines in distribution work. When we see the effect of certain waters on the interior of cast iron pipe and distribution mains and when we take into consideration the effect that tuberculation has upon the efficiency of a distribution system so far as fire protection is concerned, I think we are going to be forced to adopt some means to prevent this tuberculation in order to keep the cost of replacement within reasonable limits.

I can add very little to Colonel Maury's paper. He always writes so thoroughly when he presents a paper to us that he does not leave much room for argument or discussion. I should like, however, particularly to emphasize the necessity of making a study of each individual problem for the purpose of selecting the proper material for long supply lines.

Mr. E. G. Ritchie:[5] I should like to say a few words on the subject of wrought iron and steel pipes. I am from Melbourne, Australia, and have had considerable experience in the use of pipes of the different classes mentioned by Mr. Maury, but particularly in iron and steel pipes for supply of a city of 900,000 people, which is growing at present at the rate of close upon 40,000 additional population per annum. We have about 135 miles in length of wrought iron or steel pipes, mostly steel, varying in diameter from 18 to 57 inches of which 65 miles have been laid under my supervision, the whole entirely of Australian manufacture. We have lately contracted for a supply of 27 more miles of pipes, included in which is an 18-mile length of electrically welded pipes varying from 46 to 54 inches diameter.

[5] Engineer of Water Supply, Metropolitan Board of Works, Melbourne, Australia.

Our first wrought iron pipe was laid in 1887 on a length of about 6 miles and was 30-inch diameter. It was riveted pipe with faucet and spigots with lead joints and about the year 1921, i.e., after 34 years life it was renewed. Now, our experience was this, the coating, originally of a mixture about 50 per cent Trinidad asphalt and 50 per cent coal tar, had more or less perished, and the internal incrustations had materially reduced the carrying capacity of the pipes. Moreover, on a length of about half a mile we had been having a fair amount of trouble due to leaks from perforations, as a result of external corrosions. We figured that so far as that half mile was concerned it could cost us no more to pay the interest on the cost of a new pipe than to continue to bear the cost of repairs. We decided therefore that, under all the circumstances, it would be wise to renew the whole 6 mile length of main. I fully contemplated that we would be able to put back most of the main, after repairs and re-coating. Our plan was as follows: for the upper or low pressure sections of the main, about one mile in length and with maximum head of 75 feet, we put down a new reinforced concrete pipe made by the Hume centrifugal process. I figured that with this mile of steel pipes not replaced we would have a sort of reserve from which renewals to the pipes to be repaired would be drawn, where the latter were found to be "beyond repair." We took the opportunity of winter time when the main was not in use to lift the 5 miles of pipe not yet dealt with, carted them to the nearest factory, cleaned them, patched them or put in new rivets where necessary, recoated them and relaid them with every expectation that they still had a long term of useful life to give. Now the net result of our operations was that after relaying the 5 miles of pipe, I had nearly all the first mile of pipes, lifted as a reserve, still on my hands, and as a matter of fact, our loss of the original pipes, i.e., the sum total of pipes abandoned as too costly to repair was only about 2½ per cent of the total length of 6 miles originally laid. And from what I have observed in the use of mild steel pipes, I should expect results which, though perhaps not quite so favorable, would still compare very well indeed with the results achieved on those old wrought iron pipes, especially as our present day methods of coating are much superior to those employed on the old wrought iron pipes, I believe referred to.

I may say that we have used all classes of steel pipes. At first, we used riveted pipes, which we have long since ceased to employ,

on account of the fact that they are at best only a 70 per cent efficient pipe, as far as strength is concerned, and there are many objections to the presence of rivets in such a structure. (This remark does not apply to spirally riveted pipe but refers to the ordinary longitudinal and traverse straight riveted pipes as commonly used for larger sized pipes.)

In 1912 we used our first lock bar pipe and in our latest patterns we are using electrically welded pipes on which an automatic welding machine is to be employed. Both the lock bar and the welded pipes are 100 per cent efficiency structures.

The questions that arise in my mind, as a result of my own experience is, "When is a steel pipe worn out?" "In the large number of cases will it even pay you to let it wear out?" I have figured out that the time will surely come when the cost of repairs due to perforations will be such that it will be sound business to take the pipe up, patch it and recoat it and use it again, if not in the same place, at least in some other place. For, wherever it is in roads subject to traffic, it is doubtful whether you can leave it to its fate when its repair bill is becoming unduly high. There would be the danger, with water removed from the pipes, of eventual collapse in the roadway and, while under a concrete roadway, this collapse might not really take place due to the supporting action as a beam which the concrete possesses, still I cannot think it would be good engineering to leave that main there. Even if you could leave the steel pipes to the absolute limit of their life, and lift them and cart them away, it would always be the problem of cost of carting worthless pipes, and the difficulty of finding a disposal place for them. It, seems to me, therefore, a much more rational plan to lift them in good time, repair them where necessary and re-coat them, and again I would ask the questions. "What is really the limit of life of a steel pipe under such circumstances, i.e., taking into account the economic necessity for re-conditioning the main rather than allowing its complete destruction?" I think the answer would be that it is really very much greater than we ever supposed when we made our original calculations at the time it was first laid down.

Mr. C. B. Burdick:[6] The Association is indebted to the author for a large amount of valuable data on pipe lines. It is particularly useful thus to assemble estimates of cost on a comparable basis.

[6] Consulting Engineer, Chicago, Ill.

The financial comparisons of the several kinds of pipes are enlightening, even though there may be room for differences of opinion, as to values assigned. This general method of comparison, carried to its logical conclusion in each case, is the method by which this and other engineering problems must be attacked, unless a correct conclusion may be made from general experience.

The comparisons made by the author presuppose that, under the conditions outlined for his comparison, all four of the types considered are substantially equal except as regards the factors he mentions, namely cost, carrying capacity, life and leakage. Cast iron, steel and wood, have been used sufficiently long so that good results would be generally expected by engineers. While concrete has amply demonstrated its usefulness under gravity flow or moderate pressure, the knowledge of its use under higher pressures is rather limited. Within the next generation some things will be proved, upon which most engineers can only speculate today. We are fortunate to have the author's views on the use of this material, for he has had an unusual opportunity to study the problem recently.

It is suggested that it would add to the usefulness of the paper, to record the principal features of design for each kind of pipe, particularly the working stresses. The iron pipes and the steel pipes are very conservative in shell thickness, and data are scarce as to workable values for concrete pipes. Upon gravity supply lines, controlled from the upper end, with the relief towers mentioned; it would seem that a well-coated steel pipe might have a somewhat thinner shell, than has been used in the author's tables.

There are certain situations in which any of the pipes mentioned would be eliminated from consideration, or suffer serious disadvantage in comparison to the others. One city is in mind, served by a water capable of tuberculating well coated cast iron pipe with such rapidity as to reduce its carrying capacity 60 to 80 per cent in seven years. A cement lined pipe or a wooden pipe has important advantages at this place. In many plants, cast iron pipe progressively decreases in carrying capacity with age. This fact is so well recognized that a correction for age accompanies Weston's flow tables and the speaker has noted that, while individual lines of pipe could barely be expected to check the age-friction coefficient, the newer pipes and the average of the older ones do not miss it very far.

Steel pipes in the larger sizes, particularly under the higher heads, have an advantage in dependability particularly in main discharge

lines. Well protected steel pipe has been used sucessfully at Gary, Ind. for the past 16 years in the city distribution system, in sizes down to 6 inch diameter. The comparatively high friction loss in riveted steel pipe can be reduced by a cement lining, at a reduction in the total cost of the line per unit of carrying capacity, at the same time considerably increasing the life of the pipe.

In the far west *cast iron* suffers a heavy freight charge, and there are many enterprises in which its cost is prohibitive, as creating an investment impracticable of finance. In such places wood and steel have formed a most useful field, and concrete, if successful as a pressure pipe material, will be welcomed, as it promises a long useful life. In the eastern and middle states long supply lines are rare. The west however is going *far* for its water and the economies of main supply lines are vital to such water projects.

Mr. Wm. Gore:[7] The paper by Mr. Maury is of exceptional value to waterworks engineers and there is much of interest to be discussed in it, but I would like to confine my remarks to the problem of the protection of cast iron and steel pipes from corrosion. During the discussion so far the inference has been given that the coatings of cast iron and steel pipes as now applied by dipping or painting are satisfactory. That has not been the experience of the speaker.

It is well known that not only does a defective coating shorten the life of a pipe but it also reduces its discharging capacity seriously during its active life. This is particularly so when the waters conveyed are soft or contain organic acids which dissolve out such impurities in the coating as calcium carbonate making the coating porous and permitting nodulation inside the pipes. Examination discloses the fact that this nodulation occurs even when the coating, if thin, appears to be intact, but undoubtedly porous. The case is bad enough with cast iron which has a surface permanently linked up to the main body of the metal but it is much worse with steel owing to the mill scale which has a tendency to crack away particularly due to the bending process of pipe manufacture and while at the time no amount of scrubbing with wire brushes will remove it yet later on it comes away, taking the coating with it and leaving the metal exposed in patches. In some industries it has now become common practice to allow the mill scale to rust off completely before a coating is applied with satisfactory results, but this would be difficult or

[7] Consulting Engineer, Toronto, Ontario.

impossible with water pipes. The Coolgardie pipe line experienced considerable trouble due to defective coatings. The discharging capacity of this pipe along some sections after five years of use was reduced by 44 per cent. Examination of the inside of specimens of the pipe sent to England showed the coating almost entirely to have disappeared and upon the surfaces were a number of rust nodules up to about half-inch in diameter. The greatest surprise to the speaker and those he was associated with was that the discharging capacity of the pipe was reduced so much by the small amount of nodulation observed. The conditions of laying the Coolgardie pipe were especially trying and the discharging capacity fell off the most where the pipes had been exposed for about two years before being placed underground.

Recently in the case of a short length of 42 inch steel pipe painted with a standard asphalt composition the pipes were not well on the work before serious breaking away of the mill scale became apparent, necessitating repainting before laying.

The two cases cited may be exceptional but it is a world wide experience that a time diminution in the discharging capacities of both cast iron and steel pipes does take place which would seldom take place if a really satisfactory coating could be found, but concrete and wood stave pipes have the advantage that in most cases it becomes unnecessary to consider a time diminution of their discharging capacities. This is well brought out by the author in the working financial comparison in the case of a 54 inch pipe for all four classes. The most important item of cost is undoubtedly the first cost of the pipe laid in place. In the case of a 42 inch and 36 inch pipe at present under consideration, it is the intention to ask for bids for both steel and concrete pipe, cast iron for reasons of cost and wood stave for other reasons being out of the question. In this way we hope to be in a position to draw sound and satisfactory conclusions as to the best pipe for this case.

Mr. Wm. W. Brush:[8] I agree with Mr. Gore, that the important question from the water works viewpoint, as to the distribution pipe, is the coating, both for cast iron and steel pipe. The dip tar coating as generally applied is acknowledged by all to be unsatisfactory, and yet the majority of us continue to accept it, knowing

[8] Deputy Chief Engineer, Department Water Supply, Gas and Electricity, New York, N. Y.

that with even a mildy carrosive water such as New York uses, within twenty years the loss in the carrying capacity of the pipe will approximate 30 per cent. We should give up buying cast iron pipe of the larger diameters with the present dip coating, and, so far, Portland cement appears to offer the best protective coating for water mains. The manufacturers will give us both large and small pipe with any coating that is generally demanded, and the price will be dependent upon its cost. In recent years New York City has installed many miles of 66 and 72 inch steel pipe coated with what is known as "bitumastic," and also installed a two mile line of 36-inch cast iron submerged pipe, coated with "bitumastic." This coating has been used in New York for approximately eight years, and has been shown to be far superior to the dip coating.

The question of the coating and the resultant life of metal water pipes brings to the forefront the very vital question as to whether large cast iron pipe should or should not be installed under city streets. If a cast iron pipe breaks, usually a large section of the pipe gives way, and in the case of a 48 inch main the resultant flow may be at the rate of approximately 100 m.g.d. This flow quickly floods cellars and subways, destroying a large amount of pavement, and there is a resultant heavy monetary damage. A steel pipe may fail, but only by pulling apart, and the rent in the pipe is very small as compared with the area of the break in a cast iron pipe.

I understand that in Melbourne, Australia, only steel is used for pipe larger than 18-inches in diameter, due to the damage caused by breaks in the larger mains.

There is no more important question before the water works fraternity today than the question which has been brought up by Col. Maury in his paper, and we must give intensive thought to the solution of the problem, as to the material and coating that is best suited for both large and small size pipe, whether the material be of cast iron or steel. Col. Wood of the Board of Water Supply will be able to give you some details in reference to tests of coatings that were made on one of the New York steel pipes.

Mr. Leonard P. Wood:[9] The Board of Water Supply of the City of New York during the past ten years has laid many miles of large steel pipe from 66 inches to 11 feet 3 inches in diameter under two

[9] Assistant Engineer, Board of Water Supply of the City of New York, N. Y.

entirely different sets of conditions. The larger pipes are parts of the Catskill aqueduct which brings water from the Catskill mountains to the City. These were laid as so-called siphons across such of the valleys as were not crossed by pressure tunnel. These pipes ranged from 9 feet 6 inches to 11 feet 3 inches in diameter and were all lined with two inches of Portland cement mortar and protected on the outside by a jacket of Portland cement concrete and an earth embankment. Ten of these pipes were entered last year after 6 to 9 years of service and, while not examined throughout, the mortar linings, whenever seen were found practically perfect. Of course, they were covered with slime as the interior of an aqueduct usually is, but the condition of the 2-inch lining was substantially as good as new, except that the surface was slightly softened and showed a slightly sandy texture in place of the almost polished surface left by the steel forms. This mortar lining promises to have an indefinite life. The only failure of the lining was at overhead stream crossings where the pipe, unprotected on the outside except for a 2-inch mortar envelope, had been exposed to severe winter cold. Here frost had spalled the mortar lining at the top of the pipe. In only one case has a mortar lining been dug through to the steel, this being a case where the mortar was obviously defective, and the steel, which had been pickled to remove mill scale, was found bright and entirely free from rust.

The other group of steel pipes consists of lines in the City streets; of these about 5½ miles of 66-inch pipe were laid about 10 years ago. Most of this pipe was coated with one of the asphaltic dips in general use at that time. On one line, to which Mr. Brush has referred, about a dozen experimental coatings of different kinds were put in for comparison with the asphaltic dip. In 1922, through the courtesy of Mr. Brush, there was an opportunity to examine with him the interior of that part of this line containing 9 of the coatings including the asphaltic dip. Of these 9 coatings, bitumastic enamel was found to have given by far the best protection to the steel, the tubercles being much fewer and smaller than with any of the other coatings. This bitumastic enamel is a highly refined coal tar having such a high melting point that it has not yet been successfully applied as a dip but has to be brushed hot on the specially prepared pipe. The superiority of this bitumastic enamel over the other coatings examined was such that it was adopted for the coating of

14 miles of 66-inch and 72-inch steel pipe in the City streets, for which contracts were at that time in preparation, and most of which pipe has since been laid.

About 1916 the Board also laid about two miles of 36-inch flexible joint cast-iron submarine pipe under New York harbor. This submarine pipe and some of the approach piping was also coated with bitumastic enamel. When portions of this submarine pipe were examined about two years ago, the pipe was found in excellent condition both inside and out, the inside being in much better condition than adjacent cast-iron pipe coated with the usual coal-tar dip and than valves, etc. which had been painted with a cold asphaltic paint. In view of this showing, bitumastic enamel was adopted also for a new 42-inch flexible joint submarine cast-iron pipe now being laid in New York harbor.

With most soft waters and some soils, both the life of a steel pipe and its carrying capacity are determined by the life and efficiency of the protective coating. The mortar-lined pipes described seem likely to have a useful life equal to that of a masonry aqueduct. In the asphalt-dipped pipe, carrying the same water, pitting under the larger tubercles had penetrated one-fifth to one-sixth the thickness of the 16-inch plate at the end of 6 years; unless sooner recoated this pipe may be expected to show such leakage as to require extensive repairs under 30 years. The enameled pipe laid at the same time and in the same line promises to have not only a longer life, but, because of the fewer and smaller tubercles, to show at all ages a higher coefficient than the asphalt dipped pipe.

Mr. J. E. Gibson:[10] I do not want to discuss Col. Maury's paper. I think he has pretty well covered the field, but during the war period Colonel Maury happened to be my boss, and he insisted upon our laying wood pipe. I objected strenously; I like to kick anyway and I kicked on the wood pipe, but he rammed it down my throat. We laid about 30,000 feet of 20-inch continuous stave wood pipe, under a guarantee of 150 pounds pressure. After he got it laid and we tested it, we found the leakage to be somewhere in the neighborhood of about 200,000 gallons per day of 24 hours. The contractor got busy and ultimately reduced that to about 800 gallons per inch per mile, or about 80,000 gallons per day. We do not operate that however under 150 pounds pressure, but about 135 pounds, and since then our leakage has gradually grown

[10] Manager and Engineer, Water Department, Charleston, S. C.

very much smaller than that, and I think today it is running less than 300 gallons per inch per mile.

Recently our county sanitary drainage commission who have charge of the highways, undertook to take an elbow out of the road, so that in taking this elbow out they would cross our wood main twice at a very sharp angle, about 350 feet of the pipe. I was afraid to leave the wood pipe under the improved pavement and undertook to relay cast iron pipe and in so doing had occasion to move the wood pipe some 2 or 3 feet horizontally and raise it some 6 feet at one point. I could not very well shut the main off, so I finally took the bull by the horns and moved this pipe with the water under 110 pounds pressure, the same as you would ordinarily move cast iron pipe. I must say that with very little additional trouble, except that we had to be a little more careful than with cast iron pipe, because it was a new undertaking, we moved the pipe, got it into the new location and then cut in our parallel cast iron main. Now there is one point about the carrying capacity of wood pipe, that is, unless the pressure or the staves are of sufficient thickness to retain their round shape, you will find a very decided falling off in the carrying capacity. In other words, if the pipe, due to the lack of pressure and the overhead burden of the ground, takes an elliptical form, you will get a lower discharging capacity.

Now about lining or coating, about two years ago, at Philadelphia I think it was, I said that very few of us knew anything about the carrying capacity of the pipe. I gave my experience at Charleston, S. C. Quite a few of the members at that time said "Oh well, you have a peculiar water down there; it does not exist;" but what I have heard here this evening sounds like mighty good cheer to my heart; it shows that we are not exceptional at Charleston. I find you are all getting this incrustation. I will tell you too that the quantity and thickness of the incrustation is due to the little tubercles, the size of the end of your finger, that set up eddy currents that restrict a six inch main to four inches, and a 24 inch main to 20 inches. There is only one answer to that, coating, cement lining inside and out. We first got one of the pipe foundries to line pipe for us; it cost us about $5.00 a ton on the first work we did, about 15,000 feet of pipe from 24 inches down to as little as 4 inches. We worked it out together. We used natural cement about a quarter of an inch thick. Today you can get cast iron pipe lined with Portland Cement placed centrifugally, less than an eighth of an inch thick, and the inside surface looks like porcelain. I am told that the cost is little, if any,

over the ordinary tar coating that you buy from the foundries today.

Mr. Gustav J. Requardt:[11] Colonel Maury has touched upon four cardinal points, beside several minor ones, to be considered when comparing material in large supply mains, and the information contained in his paper is extremely valuable. I might suggest three other points, which in some cases will have important bearing. These may be titled: fluctuating value of money, obsolescense, and future surface improvement.

After every war, costs of materials rise to a new level and larger bond issues are required for new construction; also, cheaper money can be used to pay off old bond issues. Such a condition favors the installation of the main constructed of material with the longest life since it will seldom need replacement; thus necessitating fewer bond issues and sinking funds may be set for longer periods.

In many cases, the main is designed to have a carrying capacity suitable to meet the demand which will prevail probably at the time the full life of the pipe is spent; in other words, an attempt is made to have the main serve its full usefulness for its whole life or that obsolescence be the same as depreciation. When this is considered in comparing materials for mains which have different durabilities, it is likely that smaller diameters will be selected for those materials with the shorter life. This would seem to favor the installation of wood over cast iron pipe, although several replacements with continually increasing diameters and on a rising cost curve may offset this apparent advantage.

Supply mains originally constructed in open country may be greatly built over as the time for replacement comes around, as cities sometimes expand amazingly in several decades. Paving and other surface structures are expensive, and their removal and replacement must be added to the cost of the main replacement when that becomes necessary. This consideration would favor that material which has the longest life and requires the fewest replacements.

The above three points should be considered where conditions are such that they apply in addition to the factors which are ordinarily considered and which were discussed so ably by Colonel Maury.

Mr. T. H. Wiggin:[12] There are a few matters in connection with the Catskill Aqueduct work which might be added to Mr. Wood's discussion. The speaker is no longer connected with that work but

[11] Consulting Engineer, Baltimore, Md.

[12] Consulting Engineer, New York, N. Y.

was designing engineer in charge of the development of the cement-lined, concrete-covered pipe for the inverted siphons. The siphons, except where there are pressure tunnels, are constructed generally of three lines of steel pipe. Mr. Wood has mentioned that these lines vary from about 7 feet 4 inches to 11 feet 3 inches in diameter of steel shell and in determining their design a rather interesting economic comparison was made which was very much along the lines of the author's paper under discussion. It was possible to make these siphons of four unlined pipes, having a coefficient in the Chezy formula, $v = c\sqrt{rs}$, of about 85, which was as high as we dared assume, or it was possible to use three smaller lines of cement-lined pipe, assumed to have a coefficient of about 120. It was found that the cost of these three lines, cement-lined and concrete-covered, was about the same as the cost of the four lines, but when account was taken of the greater life of the cement-lined and concrete-covered pipe, the comparison came out considerably in favor of the latter as compared with the four lines not so protected.

After the first seven or eight years experience with the Catskill works, two more lines were laid. It ought to be explained that, by reason of the siphons being made of a triple line of pipes, it was possible to defer two of the three lines for some years. When it was time to draw contracts for the second and third lines, various gagings of the first lines were available, some of which were made as much as five years after these first lines were put in service. The coefficient proved very satisfactory. Instead of approaching 120 (in the Chezy formula, $v = c\sqrt{rs}$) as was assumed very conservatively in the initial design, coefficients of only two siphons were below 140 and the general average was about 157 as shown in a little greater detail below.

DATE OF GAGING*	NUMBER OF SIPHONS GAGED	COEFFICIENT IN FORMULA $v = c\sqrt{rs}$.		
		Average	Maximum	Minimum
1915	7	164	165	163
1919	13	157†	173	130‡
1920	2	156	169	142

*Made by F. F. Moore, Designing Engr., B. W. S.

†The same 7 siphons that were gaged in 1915 gave in 1919 average 164, maximum 168, minimum 157.

‡Two siphons near Ashokan reservoir gave 130 and 131 respectively, probably because of the greater fouling by vegetable growths often noted near reservoirs. Excluding these two, average is 162 and minimum is 151.

Because of these favorable coefficients, also smaller losses than allowed found in siphon chambers and other refinements in the hydraulic computations, the second and third lines were made considerably smaller than the first lines. In the shorter siphons the reduction in one case was from 9 feet 2 inches finished diameter (9 feet 6 inches shell) to 7 feet (7 feet 4 inches shell). In one of the longest siphons, where influence of pipe coefficient was paramount and not obscured by the changes in siphon chamber losses, the reduction was from 9 feet 2 inches finished diameter (9 feet 6 inches shell) to 8 feet 2 inches finished diameter (8 feet 6 inches shell). As far as economy of deferring the second and third lines is concerned, this economy did not materialize, because in the meantime the price of material had increased so greatly that perhaps it would have been money in pocket to have placed all three pipes in the first place and of the larger size.

The so-called City pipe lines, or extensions of the Catskill Aqueduct in the streets of New York, were not cement-lined and concrete-covered. It was thought that pipes 66 inches in diameter were as large as could be put in the streets without too many alterations in sewer pipes below and in gas and other shallower pipes above. Considering that 48 inch (cast iron) was the largest pipe theretofore used in the streets of New York City, 66 inch was a considerable step. To cover them with concrete would have added 12 inches to vertical and about 24 inches to horizontal diameter. Without a concrete envelope or other stiffening device, such as steel flanges on the outside of the pipe, mortar lining was believed to be insecure.

With the idea that steel pipe protected by dip or paint would continue to be used, the experiments with coating described by Mr. Wood were inaugurated. The cast iron flexible-jointed submerged pipe across the Narrows in New York harbor had already been the occasion for seeking the best coating obtainable at any reasonable price. This same kind of coating, Bitumastic enamel, a refined coal tar product, was used experimentally on a considerable scale in the first 66-inch steel pipe laid in the City and after successful service for 7 years became the standard protection for these large steel pipes in the City.

In conclusion, the speaker would suggest that Col. Maury might well include not only mortar-lined steel pipes, but also mortar-lined cast iron pipes, which have been giving such satisfactory service at

Charleston, S. C., in his instructive series illustrating the kind of economic comparison that should precede choice of type of pipe.

A Member: How long after those pipes were placed was that test made in which a coefficient of 150 was obtained?

Mr. T. H. Wiggin:[12] About 5 years.

A Member: Tell us how smooth the pipe was finished compared to the pipe on exhibition in the manufacturers' exhibit.

Mr. T. H. Wiggin:[12] The lining was accurate in alignment and smooth as to surface. Most of the pipes were coated by pouring mortar around a wooden form and trowelling off any roughnesses existing after removal of forms. The proportion of the mortar was 1 to 2. One of the siphons was lined with a cement gum and trowelled smooth. Mr. Wood can describe in detail what the surface looked like after several years. It is a little more sandy than originally, showing a slight solution of the slick surface existing when the coating is first trowelled.

The mortar-lined and concrete-covered pipe was a very successful experiment. Of course, it was not an experiment in a sense, because mortar-lined and covered steel pipes were used so many years ago up through New England and in other parts of the country, so that we had a perfectly good line of experience, except that the Catskill Aqueduct pipe was very much larger, running, as said, up to 11 feet 3 inches in diameter. This large pipe required stiffening so that the lining would not collapse afterwards, because such a big pipe, when the pressure is removed, will flatten six inches or so and the lining inside would be likely to be cracked off. In the smaller pipe that difficulty does not exist.

Mr. T. A. Leisen:[13] I might say on this question of coating, I am somewhat in the same position as Mr. Brush, as Chairman of the Committee to prepare standard specifications for steel pipe, I ran up against the same trouble, and the matter has been delayed, not because of the difficulty in preparing a specification insofar as it applies

[13] Secretary and General Manager, Metropolitan Utilities District, Omaha, Nebraska.

to the steel, but in connection with the coatings, and principally on that account the specifications will not be offered at this meeting of the Association. On the question of the deterioration of the coatings, so far as my experience goes I may say that in conversation last evening with the chief engineer of the Wilmington Water Department regarding a line of lock bar pipe laid by the speaker about 18 years ago, he informed me that they have been examining that pipe at least once each year and sometimes more frequently than that, and in the last examination made quite recently, the coating was found practically intact at the points where it was examined with no evidence of deterioration after a period of 18 years. About 2 weeks ago in making a 36 inch connection to a 48 inch line laid 12 years ago in Omaha, a section was cut out and carefully preserved, and the coating was still on, although it did show some evidence of blisters, and the coating was also covered with a slimy substance due probably to the lime in the water used at certain periods before the filtration plant was constructed, but the steel under the coating was in practically perfect condition. Those are the only two cases recently observed.

Mr. D. H. Maury:[2,14] This Association is to be congratulated on the fact that so many engineers of wide and varying experience should have taken the time to contribute discussions of this paper, discussions which were so instructive in their character and covered so wide a field, that they form a more valuable contribution to the Society's publication than does the paper itself.

One member in discussing the paper brought out the fact that the choice of the proper pipe to be used would not always be made solely on the basis of financial allowances for capacity, leakage and durability, and that there were sometimes certain conditions which might eliminate altogether the consideration of one or more of the classes of pipe discussed.

This is perfectly true; but the three points for which allowances were made are the three most important points to be considered; and in the example presented showing one method of computing these allowances, the assumption was made that the physical conditions would be such as to permit the use of any one of the four pipes concerned. The author believes that these allowances should always be computed before reaching any final decision.

[14] Author's closure.

One factor, however, which is not a physical factor and for which no financial allowance can be made, may nevertheless in some cases strongly influence the selection of the pipe to be used.

This factor is the mental attitude of the client toward one or more of the classes of pipe under discussion. For example, there are men who staunchly maintain that, no matter what the physical conditions may be, they would never consent to the laying of wood stave pipe on any project under their control. Sometimes such men may be persuaded to forget their prejudices and to give this class of pipe its due, subject always to the limitations of its field of usefulness. This field is narrowed by the fact, stated in the paper, that there are certain conditions under which wood pipe should not be used at all.

There are other men, however, with whom it would be utterly useless to argue. You may put before them allowances such as are presented in the paper and explain these allowances step by step; the prejudiced client may agree with every step of the explanation and argument; and then, when the end has been reached and after the figures have shown that every conceivable allowance for physical conditions has been taken into account and reduced to a dollar-and-cent basis, and that the wood stave pipe is still the cheapest, the prejudiced one may still say, "Well, that's all right, but I would not use the wood pipe anyhow."

One of the most interesting points brought out during the discussion of the paper was the practicability, already demonstrated in several installations, of applying a thin and smooth lining of cement to the interior of cast iron and steel mains. The author believes that further development along this line may lead to great benefit in the future, for it is certain that most, if not all, of the coatings now commercially obtainable fail to prevent the formation of tubercles inside the pipe, or to give proper protection to its outer surface. On the other hand, as brought out in the paper itself, long experience with cement lined iron or steel pipe has demonstrated that its carrying capacity is not seriously diminished by age, and that the cement lining affords a practically perfect protection against the corrosion of the metal by the water in the pipe.

With these two facts established, the author believes that we may expect to see noteworthy developments in pipes having a steel shell, coated inside and out with cement or concrete. Whether in the design of this pipe the steel shell itself will be relied upon entirely to resist the internal pressure, or whether the steel shell will be thin and will

be depended upon, not for reinforcing strength, but solely as a water-tight diaphragm, the necessary reinforcement being provided in the form of steel bars or mesh, will be a question that can only be decided in the light of the local conditions and of the respective costs of the two classes of pipe.

The author is particularly fortunate in that his paper was discussed by so many of his personal friends, and for their complimentary remarks he wishes to express his grateful appreciation.

GOVERNMENT REQUIREMENTS AND PROFESSIONAL STANDARDS[1]

By George C. Whipple[2]

In connection with recent service on several committees, the writer has had occasion to consider questions of "standards," "government requirements," "grades of quality," and the like, and has observed that much confusion exists in regard to the whole subject. There is a strong tendency nowadays to standardize and grade, to classify and "score," and there is also a desire on the part of many to have all this done by government. Some of the suggested laws and regulations looking to this end are of questionable legality; and it is probable that some sections of existing building codes and health laws would be declared unconstitutional if fully presented before the courts. It ought to be profitable, therefore, to consider the fundamental principles involved and a few of their applications.

POLICE POWER

When government makes a requirement in regard to the quality of food or water or sets up a building or plumbing code, it acts under what is called the "police power." This is an element of common law. One finds it in court decisions, not in statutes. It has never been exactly defined. The United States Supreme Court has even refused to define it. Usage has established the principle that its purpose is to *prevent injury*, not to produce benefits; to prevent the bad, not to secure the good. Its recognized scope is to prevent injury to the health, safety, morals—and some recent decisions have included welfare—of the people. Under the police power government may prevent the use of water likely to injure the health, may prevent types of building construction which threaten safety, may require certain protective devices in house drainage systems, and so on.

[1] Presented before the New York Convention, May 21, 1924.

[2] Professor of Sanitary Engineering, Harvard University, Cambridge, Mass.

Government may, of course, do things for the public benefit, may undertake *service* of one kind and another, may give advice, provide education, and in various ways endeavor to better conditions; but service is a very different thing from compulsion to prevent injury. Attempts at compulsory betterment by law have indeed been attempted, but, regardless of constitutionality, have not been successful.

GOVERNMENT REQUIREMENTS

There is often a disposition to regard a government requirement as a standard of excellence. Minimum requirements tend to become maximum practice. It is said that when, in Massachusetts, a minimum requirement was set for the amount of fat in ice-cream, some dealers who had been supplying products well above the requirements reduced the amount of fat to figures just within the law. The law prevented the bad; but did not tend to make the good any better. If a requirement is made too low, there is danger that this scaling down will occur; if it is made too high, it is likely to work injustice to many. Even if it is reasonably fixed between high and low, the effect is likely to be one of leveling. The trouble comes from the regard which the public has for law, a governmental minimum requirement being complacently viewed as adequate.

PROFESSIONAL STANDARDS

Professional standards ought to be higher than legal requirements. How absurd it would be to let law govern the fine arts! In Boston the police power is used to prevent hand-organs from playing if they are out of tune, and there are laws controlling billboards, but these do not set standards of excellence for either music or painting. Licensing doctors, lawyers, engineers, or plumbers may protect against incompetence, but does not encourage high ability. On the contrary, it exerts a leveling influence. In college, students are not given a degree unless they attain a "passing grade," which unfortunately represents mediocrity, not excellence. The D or E man is penalized by college law; no college regulation can force a man to get A's and B's. Stimulation to work for honors lies elsewhere. In many fields of business and even in structural work and sanitation where matters of health and life are involved, some persons are content if they just get by the law, and the public innocently

assumes that if the law is complied with that is enough. It ought to be reiterated by professional men, until the people understand it, that what the law sets up are not standards of excellence but limits to inferiority.

One reason why people get this false impression is because legal regulations sometimes go too far and too much into detail. This is true, for example, of plumbing regulations. Some of the codes are veritable specifications, obviously intended to improve practice and force people to install what is best. The underlying motive was good, and we should find no fault with such codes except this—that they ought to be set up as standards by the plumbing crafts and not made compulsory by law. Legal requirements concerning plumbing should go far enough to protect against injury to health, morals, and safety, keeping in mind that old plumbing causes more trouble than new plumbing and that protection needs to consider the future as well as the present, but this can be accomplished by relatively simple rules. If legal plumbing regulations were simpler and people got in the habit of depending upon the integrity and competence of plumbers themselves, instead of assuming that these men are merely complying with the law and skimping if they can, the present popular feeling against this craft would gradually clear.

In my opinion there is a wonderful opportunity for the professions, the crafts and the labor unions to establish and uphold standards of excellence. Let the public look to government for protection against the bad and the unsafe, but let it get in the habit of looking to these organizations for advice and coöperation in procuring what is best.

STANDARDIZATION

There is a strong demand also for standardization, especially standardization of the dimensions of things. There is need for the elimination from trade catalogues of many little-used articles, for "simplified practice" as Secretary Hoover calls it. This movement has already made head-way in several branches of the building trade. It is badly needed in the field of plumbing. When the Sub-Committee on Plumbing of the Building Code Committee of the United States Department of Commerce began its labors, it took up the subject of standardization, but, after devoting much

time to it, reached the conclusion, stated in its final report, that standardization is desirable but should be brought about by agreement and not by law. Unfortunately standardization in plumbing supplies and devices cannot be brought by agreement as long as it is hampered by having different legal regulations in different states and cities. The present chaotic condition of the plumbing laws stands in the way of a reform which would result in great economies. The adoption of a simple plumbing code substantially uniform in different states is needed not only for its own sake, but because it will make possible the standardization of dimensions and quality of plumbing supplies. Some of the plumbing regulations are matters of concern to water works engineers, and the movement to secure uniformity, under the leadership of the Department of Commerce, should receive the hearty support of the American Water Works Association.

Standard specifications issued by this and other associations, notably the American Society for Testing Materials, are professional standards, and their general use shows that it is not necessary to have them forced upon people by law.

GRADING

From time to time efforts have been made to grade or score water supplies according to their quality. Sometimes three classes have been proposed—good, bad, and indifferent. Sometimes five classes have been made—A, B, C, D, and E—the first three being regarded as passable, the last two not passable. Sometimes scoring on a basis of points or percentages has been tried. Comparisons such as these are useful and have their place; but their place is not the law. Viewed with reference to the police power, a water supply should be regarded as injurious to health or not injurious. There must be no debatable ground. If a certain criterion of purity is established, a water supply complies with it or does not comply with it. Even if classes or grades are established for statistical or other purposes, there must be somewhere a line drawn between the acceptable and the non-acceptable, because the object of the police power in this case is solely to prevent injury to health.

Grading water supplies according to quality on a scale from excellent to bad is useful. It is an incentive to improvement. It may be done by government—for example, the United States

Public Health Service or state departments of health—but in my opinion it is better to have standards of excellence set up as professional standards, or what in this case would be a better name, perhaps, "Water Works Standards." Water works standards might appropriately be set up by the American Water Works Association working in conjunction with the American Public Health Association—the former representing the "producers," the latter representing the interests of the consumers. This is in accordance with the principle above mentioned that standardization should be brought about by agreement of all the interested parties instead of by law. Obviously, there ought to be an interlocking of professional standards with government requirements, and for that reason the United States Public Health Service and perhaps the sanitary engineers of the various states might have a part in the proceedings. If "water works standards" thus arrived at were promulgated, they would set the pace for excellence and raise the general level of quality, so that the employment of the police power to prevent the use of water below the government requirement would seldom be necessary. The maintenance of a high standard of quality should be a matter of professional pride. If standards of excellence were set up by the joint action of water supply engineers and sanitarians, it is probable that there would not be so great a tendency as now to make government requirements too high.

UNITED STATES TREASURY "STANDARD"

In 1914 the United States Treasury Department, through the United States Public Health Service, promulgated certain interstate quarantine regulations relating to the quality of water used for drinking or culinary purposes provided on cars and vessels by interstate carriers. The regulations in particular provided that the number of bacteria and tests for B. coli should not exceed certain stated figures. Although not so intended, these bacteriological tests came to be applied to municipal and other supplies, and in many instances this unintended application has caused misunderstanding and complaint.

Accordingly, in 1922 the Surgeon-General of the United States Public Health Service took steps to revise these requirements. A large committee was appointed, the labors of which are now drawing to a close. The present, therefore, is an appropriate time to con-

sider the subject of professional standards. A slight delay in promulgating new government requirements will work no damage or hardship, and if they can be correlated with a graded series of standards, which extends both above and below the United States Treasury Requirements, it will be not only appropriate but beneficial.

In 1904 a committee of the Laboratory Section of the American Public Health Association issued a set of Standard Methods of Water Analysis. They were professional standards. Negotiations are now under way looking towards their revision and joint publication by the American Water Works Association and the American Public Health Association—a logical and much needed arrangement. If this idea can be further extended to the establishment of graded scales of purity of water, based on sanitary surveys as well as analyses, the advantages will be large.

Tentative suggestions for the revised Treasury Requirements have been distributed for criticism and already claims are being made that they are too high or too low. If they are really too high, the public water supplies of many cities, which have long been used without injury to health, will not conform to them. If too low, they will be regarded as stamping with approval supplies which are unsatisfactory. The discussion has already shown that there is a real demand for a standard of excellence, but that for the government requirement to be at the same time a limit of impurity and a standard of excellence is practically impossible.

In devising "professional" or "water works" standards of quality, many items need to be considered—color, turbidity, taste, odor, chemical analysis, bacterial content, and so on. It will be necessary to decide what is meant by such terms as pure and impure, good quality and poor quality, high, mediocre, and low quality, and the like. It may be necessary to have different scales for different parts of the country. It will certainly be necessary to consider the element of time or frequency. Perhaps some such scheme as the following might serve.

Supplies approved by government

Class A. High quality all the time.
Class B. High quality part of the time; mediocre quality part of the time.
Class C. Mediocre quality all of the time.

Supplies not approved by government

Class D. Low quality part of the time.
Class E. Low quality all of the time.

The writer makes no attempt to suggest a system of grading, classification, or scoring. It is a difficult and delicate matter, but it ought not to be impossible for water works engineers and sanitarians to decide upon some classification adequate for practical purposes. The present committee working on the revision of the Treasury Requirements may itself be competent to set up professional standards as well as minimum requirements, but it would certainly be better to have these standards backed by such large and vitally interested bodies as the American Water Works Association and the American Public Health Association, instead of being sponsored by the United States Public Health Service alone.

RÉSUMÉ

Returning once more to generalities, the writer advocates the following principles applicable alike to building construction, plumbing, control of water supplies, and other matters of sanitation:

1. Government requirements, not too high, intended to prevent injury, and justifiable under the police power, to be established by law.

2. Professional standards of excellence, standard specifications, grading, and the like, higher than government requirements, to be established by agreement, not by law.

3. Government requirements and professional standards to be interlocking.

4. Government requirements to be uniform in the different states as far as practicable, in order to facilitate the establishing of professional standards by agreement.

5. Professional standards to be varied geographically, or in other appropriate ways in order to meet practical conditions.

SODIUM IODIDE TREATMENT OF ROCHESTER'S WATER SUPPLY[1]

By Beekman C. Little[2]

Almost exactly one year ago[3] there was given to this American Water Works Association the first public announcement of the treatment of a municipal water supply with sodium iodide as a preventive of goitre.

Within a few weeks after the Detroit Convention—at which this plan was explained—inquiries and comments about this treatment began to come into the Water and Health Bureaus at Rochester, where the test was being made, and they are still coming in.

They come from all parts of this country and several requests for information have been sent from municipal departments in foreign countries. Innumerable clippings from the daily press in many cities have been brought to my attention, and several of the popular magazines and health and medical journals have discussed, or at least directed attention to, the plan. Lest you get a mistaken impression, I should state that all these notices have not by any means been favorable to the scheme. They do indicate however a very wide and keen interest in the subject.

It is safe to say that the majority at present oppose, or to put it more correctly, are skeptical of the procedure and doubtful of any beneficial results. Some have been openly hostile and unreasonable in their opposition, while others I am glad to say are sincere in their disapproval, and their criticisms are earnest and helpful. Another class is open-minded on the subject and these are only awaiting further developments in Rochester before venturing any judgment on adopting the plan.

Before discussing some of these comments and criticisms it may be well to state again just what Rochester is trying to do, and how it is proceeding with this sodium iodide treatment of its water supply.

[1] Presented before the New York Convention, May 20, 1924.

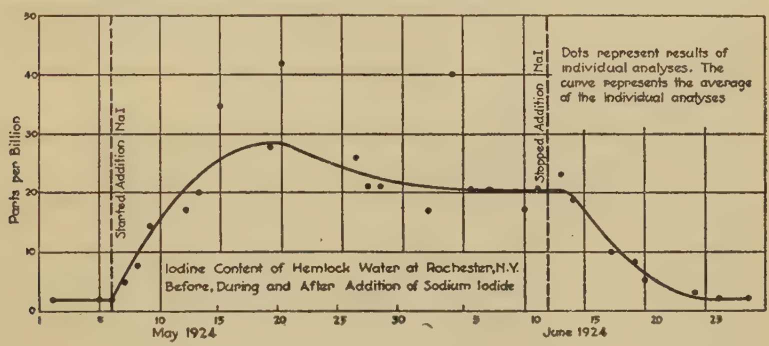
[2] Superintendent, Bureau of Water, Department of Public Works, Rochester, New York.

[3] See Journal, July, 1923, page 556.

It is the opinion now of most authorities that the disease called goitre is caused by a lack of iodine in the human system, and, in localities where goitre is prevalent, the giving of minute doses of iodine is a proper treatment.

It is the belief of the health officials at Rochester that, if every one living in such localities could receive each year this minute quantity of iodine, the disease would be stamped out. They are aided and abetted in this belief by the officials of the water bureau, and the public water supply is a means at hand by which this theory can be tried out.

In consequence, a definite amount of sodium iodide, proportional to the known consumption of water, is dissolved in Rush Reservoir, from which is taken Rochester's supply of water.



This treatment is given twice a year, once in the spring and again in the fall, and covers a period of about three weeks in each instance.

At present this seems to be the only practical way of being sure that every one—or substantially every one—in Rochester will get what is thought to be a sufficient quantity of iodine into his system.

We have been operating under this plan only a little over a year. The sodium iodide was first put into our supply in April 1923, then again in September of that year and we are now applying the spring dose for this year.

Sufficient time has not elapsed to admit of any definite results except that positively no ill effects of any kind have been noticed, other than those arising from heated arguments over the proposition. However, it may be significant that Doctor Goler, Health Officer of Rochester, states without making any claims that on a recent visit to one of the public schools he took pains to observe a large

class of the older pupils, and, counting the number of visible goitres, was impressed by the fact that there was an apparent decided decrease from one year ago. He was also quoted in the newspapers—I do not know how correctly—as saying that he did not care to make public announcement of just how much goitre there really is in Rochester. This will not give the impression, I hope, that Rochester is badly off, or worse in this respect than other cities. It merely means that we happen to be located in the goitre district in the region of the Great Lakes.

An indication of the prevalence in Rochester of this disease is a Health Bureau report that in one of our prominent educational institutions, on inspection, showed that over one-half of the 246 girls registered had visible thryoids, or in other words, goitre. It is worth while spending considerable money if this condition can be bettered. The expense of our prophylactic treatment for the community is just the cost of the sodium iodide: as the application costs practically nothing.

A contract recently was awarded in Rochester for sodium iodide at $4.35 a pound, the total cost for the entire year (700 pounds) being in the neighborhood of $3,000.00. In other words it costs about one cent a year per person.

At the Ohio Conference on Water Purification, held at Columbus last year, the preponderance of opinion, I believe, was that the scheme was wasteful and inadvisable—or as Mr. Ellms of Cleveland puts it—"it would be far more effective and much less expensive, to treat the individual for simple goitre, than to attempt the medication of an entire water supply."

To this we reply that it would be perhaps difficult and indeed expensive to find out and segregate just the individuals needing the treatment, and then to arrange for and insure each one taking his medicine. Our plan obviates these difficulties. We want to prevent *any* goitre from developing and so we treat everyone. Is not the practice of general vaccination a somewhat similar proposition, and no intelligent person disapproves of this wonderfully successful method of combatting small-pox.

A number of newspapers gave a good deal of publicity to an article issued several months ago, describing the great danger to the public of thus poisioning the water supply with iodine.

I feel that the daily press was misled somewhat and a little careless. The article was signed by a comparatively unknown doctor in a

large city, but in the newspapers he became a "prominent physician" and the pamphlet from which the article was taken was issued by the "American Medical Liberty League" which title naturally carries great weight—if you do not stop to investigate. I did investigate, and wrote to the Headquarters of the Society for enlightenment on its aims and purposes. I found that for $2.00 I could receive a book telling of the "Calamitous prostitution of science by Pasteur and how his absurd microbe theory has been demolished." For $5.00 this society would send me 100 pamphlets for distribution, containing a "crushing argument against vaccination." I could get, free, a number of blank pledges for myself and friends to sign agreeing to "Refuse and resist any compulsory medical inspection or medical treatment for myself or children, and to submit to no vaccination unless overpowered by force." Other literature sent me "because I was interested," tells how the chlorination of water has failed, and one leaflet proves by 50 tests that typhoid germs are not dangerous, and so on. There were thirty or forty pieces of this dangerous sort of reading matter sent me and yet—as stated—one widely quoted hostile criticism of our goitre preventive plan emanated from this American Medical Liberty League.

As to putting poison into our water supply, some of these same sort of critics will doubtless in a month or so complain because we did not start earlier to remove the fishy taste in the water, and for that we use copper sulphate. We are aiming at the prevention of so called *simple* goitre and some physicians have pointed out that our method might have a bad effect on some cases of exophthalmic goitre. This may be so, as I understand that some authorities hold the theory that iodine treatment in Graves Disease, or exophthalmic goitre, is deleterious. Yet Doctor McClendon of the University of Minnesota Medical School, who has studied goitre perhaps as much as any one in the country, writes me that Doctor Plummer—supervising all the exophthalmic goitre cases in the Mayo clinic at Rochester, Minnesota—has for many years been treating them with iodine, and one whole floor of the Kahler Hotel is full of these patients.

We feel that in our treatment of the water supply we will absorb no more iodine than the inhabitants in non-goitrous districts get from their food and water in its natural state.

Let me touch again upon the alleged wastefulness of our plan. An official, standing very high in the municipal government at Rochester, was quoted as saying, in effect, that most of our water

went towards sprinkling the streets and putting out fires and it was a crime to use iodine for this purpose. I think if he had fully realized what a very very small proportion of the water consumed in a city goes down the throats of the citizens, he would have made his statement still stronger. We have a consumption of 86 gallons per capita per day. The average person takes into his body—at a very liberal estimate—between two and three quarts, or less than one per cent of the total consumption. By this reasoning over 99 per cent of our sodium iodide is thrown away or wasted. If, however, we incline to this theory—and believe in it—how about our filtration plants and our chlorine installations? Why spend tremendous sums of money in making, each day, many millions of gallons of water pure and fit to drink, when we only drink one per cent of it?

It may not be absurd to look into this situation. In fact I know it is *not* absurd for I recall that a member of this Association, for whom I have a great admiration, (I think it was Allen Hazen) did delve—sometime ago—into this very question. That is, whether it would be possible or feasible to have a special system of water to be used only for personal purposes, such as drinking, bathing and the preparing of food. In a manner of speaking, we *do* waste a good deal of iodine by our plan, but the total cost is comparatively small and not to be considered at all if our goal is reached.

There is however an economic question involved. If our plan turns out to be a success and every municipality starts adopting it, what will become of the available supply of iodine and to what height will the price per pound of the commodity go?

This problem may prove to be a very perplexing one. It is possible that the process of obtaining iodine can be improved, or new sources discovered, so that the supply will meet the demand. I am not sufficiently informed to discuss this phase of the situation.

In my previous paper on this subject I mentioned the fact that salt—common table salt—had been proposed as a very good medium through which to introduce iodine to the human system. Every one uses salt in some form or other every day, and the proportion of table salt entering the human body—compared to the amount used—is very much greater than is the case with water, so the efficiency would be much higher and the drain on the supply of iodine much less.

We are not by any means certain that the treatment of water is the best way to meet the goitre situation, but at least it is *one* way, and we

think well worth a good trial. If, by exciting interest and investigation, it leads to other and better methods we will feel repaid.

There is just one suggestion I would make in closing; if you decide to start this treatment in your water supply, be sure and announce that you are putting *sodium iodide* in your water, rather than mentioning iodine. To many the word *iodine* means nothing but poison, and this fact I think has been the cause of most of the opposition that has arisen.

The details of the actual process of applying the sodium iodide has been omitted in this paper as that story has been told before, but, to any one interested, the Health Bureau or the Water Bureau of Rochester will be glad to furnish such information as may be requested.

DISCUSSION

Dr. J. F. McClendon[4] (by letter): It is with great admiration that I follow the work that is being done in the city of Rochester, New York, on the addition of sodium iodide to the city water supply. When the proposition was first put to me for criticism I had very little data for this purpose. Goiter tablets containing 10 mgm. of iodine each were being advocated to be taken at the rate of about three a day. Putting an equivalent amount of iodide in the water would be rather expensive. Other persons were advocating about one milligram a day and this, too, would be expensive.

After two years of research, I and my students have concluded that 0.01 mgm. a day is sufficient. This would be very well supplied by putting one part of sodium iodide in about one hundred million parts of water. One-tenth of a pound per million gallons would be ample. If this is not put in the water continuously, a proportionately increased quantity must be put in at intervals. The intervals should not be too long, but that part must be determined by experiment. The cost is very low.

In reply to the criticism that iodine is thus wasted in sprinkling lawns, etc. I can only answer that the iodine thus used in watering stock and irrigating food plants is returned again to the human system, and the actual waste in money is the smallest possible.

It has been shown in Switzerland that sodium iodide may be effectively given by adding it to all of the salt. Thus far, however,

[4] Professor, Physiologic Chemistry, University of Minnesota.

only half of the salt used has been so treated. Since a person is at liberty to take his salt from any source it wo'ld be necessary to iodize all of the salt in the country. Nearly a thousand tons of salt are used every year in Minneapolis to sprinkle on the streetcar tracks to melt the ice in the winter. Salt is also used for curing hides, making soda and chlorine, and for a thousand other purposes besides human consumption. Furthermore, von Fellenberg in Switzerland has shown that a large proportion of the sodium iodide added to salt is lost in storage and it must be added at least 100 per cent in excess to make sure of its being there in the required amount.

It has been claimed that the use of iodine in tablet form is the most economical. Whereas sodium iodide costs about $4.00 per pound, druggists may sell these tablets at the rate of $2000 per pound for the iodine they contain, and a special wholesale rate may be made to schools whereby the school takes on the function of retailer, and the "small" price of $1,000 per pound is charged for the iodin these tablets contain.

We can afford to waste a little iodide in sprinkling lawns and save considerable money.

As to using up the total iodine supply of the world; at present, iodine is controlled by a trust and an agreement has been made to throw away all of the Chilean supply five years out of every six in order to keep up the price.

During the war, iodine was produced in America from sea-weed off the Pacific Coast as a by-product of the potash plants. Owing to the flooding of the country with cheap German potash since the war, these potash plants have had to close down. If the demand for more iodine was made, the farmer would be benefited by more potash being produced.

The world supply of iodine is so huge (about fifty billion tons) we cannot conceive of it. At present it is nearly all in the sea but is extracted at a rapid rate by seaweed and an industry could be developed which would give helpful employment to quite a number of people in utilizing the various products from this seaweed.

Dr. George W. Goler:[5] I read Mr. Little's paper with a good deal of interest. I agree with all he says. Could I attend the meeting I should probably say something like this:

[5] Health Officer, City of Rochester, New York.

At the outset it ought to be distinctly understood that iodide of soda is not put in the water for the purpose of treating goitre. It is put there to prevent goitre. There is a distinct difference between prevention and treatment.

The only two feasible plans for the prevention of goitre are, first to iodize the water, the other is to iodize salt. We here in Rochester, as the speaker said, have iodized water. We should prefer, of course, to iodize salt. We do not believe that it is desirable to permit the child to grow to the age of 12 or 14, when goitre in this section presents itself, and then to treat that goitre with iodide. We do know that every mother should have iodide before the birth of the child. We do know that the child should have minute doses all through its life.

There can be no question concerning the value of iodide in the prevention of goitre. Iodide is just as necessary to the maintenance of the body in full health as are the vitamines. Now, if this be so, what matters how we get the iodide into the body as long as we get it in sufficiently minute quantities and get it in early?

It is said that the water method of getting iodide into the body is wasteful. We can not stop here to define this kind of wastefulness, but if it is wasteful to spend one cent per person per annum to prevent a dangerous disease then we are willing to plead guilty to the charges of wastefulness.

The question really before us is not, "how much" or "what way," but the everlasting "*how*" can we better get iodide to our people in goitrous regions so that we can prevent goitre?

Mr. Mayo Tolman:[6] From a biological standpoint there are two outstanding facts in the history of iodine; the discovery of the element in 1811 by Courtios and the detection of its presence in the tyroid gland by Baumann in 1895. Baumann's discovery was merely an incident in his attempt to secure from thyroid tissues products that, when concentrated, might represent the substance that rendered desiccated glands therapeutically useful in certain cases of goitre. Subsequent investigations were directed chiefly to discovering the function of the iodine in the thyroid. The newer investigations tended to overshadow the earlier work in this field and, for the most

[6] Sanitary Engineer, with N. S. Hill, Jr., consulting engineer, New York, N. Y.

part, the great work of Chatin, the French biochemist, seems to have been forgotten.

As early as 1850 Chatin maintained that goitre and cretinism could be averted by continued administration of small amounts of iodine. He gathered an immense amount of evidence in support of his iodine hypothesis. It was Chatin's observation that, in ascending the valleys of the Pyrenees and Alps, the content of iodine in the air and water decreased, but that goitre and cretinism increased which led him to assume an etiologic connection between endemic goitre and a paucity of iodine in nature.

Chatin's studies were investigated, in 1852, by a commission of the Paris Academy Des Sciences and many of his claims were found valid. Scientists, however, were not prepared at that time, before the demonstration by Baumann of iodine in the thyroid, to attach much importance to a mere trace of a chemical. Consequently it remained for the twentieth century to develop a plan of prophylaxis, supplying small amounts of the essential iodine where it is not easily secured in natural ways.

In my opinion Dr. Goler and Mr. Little, and with them the City of Rochester, deserve immense credit in adopting the plan of introducing iodine into the public water supply that the number of cases of goitre in their City may be reduced to a minimum.

Few people realize the extent of the disease and the disfigurement, discomfort and more that it occasions. An examination of more than half a million of school children in New York State in 1923 showed that more than 10 per cent of those examined had goitre. And it should be realized that these examinations covered the children in the non-goitrous regions as well as those in sections of the State where the disease is unduly prevalent.

In talking with me recently, an official of a State Department of Health maintained that the scheme adopted at Rochester was a waste of money, that it meant adding iodine to millions of gallons of water that were used for manufacturing purposes only and that far less than 1 per cent of the water to which iodine had been added was used for drinking purposes. Upon my making the comment that, as this country had no monopoly on salt or any other single article of diet to which the iodine might be added, as is done in Switzerland, I was told that each person should take care of himself. His contention was that with ample publicity the people would soon learn to take sufficient iodine to prevent their developing goitre.

If that is to be the attitude of our State Health Departments why should they spend small fortunes in trying to prevent syphilis when the majority of mankind knows that the number of cases innocently acquired are in a vast minority. Why do they watch the public water supplies with so much care when, judging by their attitude towards goitre, it should merely be necessary to tell the public to boil every drop they drink if they wish to avoid typhoid.

Rochester has initiated a step that must be followed by other communities in goitrous regions, and these communities will owe that City a debt of gratitude for its fortitude in carrying its tests to what must be a successful conclusion.

Mr. Scotland G. Highland:[7] Simple goitre is a common disease among West Virginia children, and is prevalent to some extent among adults. Field surveys made by the state department of health in different sections of West Virginia have revealed the fact that goitre is one of the outstanding health problems of the state. A recent examination of school children in several counties, made by the State Department of Health, local boards of health, and school boards, discloses that from 43 to 64 per cent of the school girls have simple goitre. The average for all school girls examined is 57 per cent.

It is now known that goitre is due to a deficiency of iodine in the goitre districts of the country. As a result of a practical test of universal interest, it has been pretty well established by Beekman C. Little and Dr. George W. Goler, Rochester, N. Y., that simple goitre can be controlled and prevented by supplying the iodine deficiency through the public water supply by means of dissolved iodide salts.

Wherever there is a deficiency of iodine in the public water supply, those in charge of the water utilities will wish to restore that iodine deficiency, which has been lost through long, natural processes. Therefore, a debt of gratitude is due Beekman C. Little, head of the Rochester Bureau of Water, for first giving the American Water Works Association the opportunity of broadcasting the discovery.

The people of West Virginia are watching with intense interest the research work being carried on by the Water Bureau and the Health Bureau, Rochester, N. Y., working together on a plan for treating and preventing goitre. Any new method for the prevention

[7] General Manager, Clarksburg Water Board, Clarksburg, W. Va.

of disease should first have the approval of the local medical fraternity, and the chemists and bacteriologists, before definite action is taken by the water department.

Subsequent to the presentation of Mr. Little's paper at the Detroit Convention of the Association, May 23, 1923, on "Iodine Treatment of a Water Supply as a Preventative of Goitre," there was much favorable newspaper comment in West Virginia. The people are greatly interested and most of the physicians believe that the idea advanced by Mr. Little holds considerable promise.

But later a cloud appeared in the bright horizon when Joseph W. Ellms, Cleveland, presented a paper before the 1923 Ohio Conference of Water Purification at Columbus, on "Iodine Treatment of Water to Prevent Goitre." Among other interesting things, Mr. Ellms said:

> The chlorine applied to practically all water supplied at the present time would have a tendency to decompose the sodium iodide introduced into a water and liberate iodine. While this element would not be lost, its combination with organic matter or its reaction with other mineral constituents might adversely affect its therapeutic value. It appears, therefore, to the writer that it would be far more effective and much less expensive to treat the individual directly for simple goitre, than to attempt the medication of an entire water supply.

Several months later the cloud was somewhat dissipated following a brief, but clear, discussion of Mr. Ellms' paper, by J. X. Cohen, Syracuse, N. Y., in which the latter sought to allay such doubts and fears as may have arisen because of Mr. Ellms' published address. In concluding his discussion, Mr. Cohen said:

> The facts which I have recited should serve to eliminate any fears entertained concerning the possible nullifying effects of chlorination upon iodization of a water supply in a goitrous district.

Messrs. Little, Goler, Ellms and Cohen are men of high repute, and well informed persons appreciate any conclusion reached by any one of these specialists.

The purpose of this review is to emphasize the importance of obtaining more data, and to remind research workers of the keen public interest in the subject of iodine treatment of water to prevent goitre.

Mr. J. W. Ellms:[8] Mr. Little has presented a very interesting subject and one which attracted my attention when he wrote his first paper on the treatment of the public water supply of Rochester with iodine. The Health Department of the city of Cleveland asked my opinion in regard to it, and we made some figures in order to determine what the cost would be. The best price that we could get for sodium iodide from various chemical manufacturers was about $4.25 a pound. The quantity which we would have to use, if we applied this sodium iodide to the public water supply of Cleveland for 30 days each year, would be about 3000 pounds and would cost, therefore, about $12,750 per year. As I brought out in the paper to which Mr. Little referred, the amount of water in any water supply which reaches the stomachs of the community is relatively small, and therefore, it seemed to me that this method of applying or treating the community with iodine was decidedly wasteful. It also seems to me that, even if the sodium iodide is put into the water supply, it is quite unlikely that it will ever reach the consumer, because, depending upon the character of the water, I imagine that a great deal of this material may be absorbed, deposited in some way or used up by microörganisms. I think, therefore, we may be deceived as to the real amount of iodine we are getting into the systems of the drinking public. I want to be understood as not opposed to preventive medicine, because, of course, this is in a sense preventive medicine; but the question is just how far shall we carry it? Auto-intoxication caused by the stoppage of fecal matter in the lower intestinal tract is easily relieved by Epsom salts, but whoever heard of Epsom salts being put in the public water supply of a community. Is it necessary that such be done? If we start with such a form of treatment, the question is, where shall we stop?

Mr. J. J. Hinman, Jr.:[9] I am not a representative of the League of Medical Freedom. I have been interested in Mr. Little's work on iodine for some time. I have been interested to a certain extent in the material that has been published in Switzerland and on the continent of Europe with regard to the goitre situation there. I have some doubts about the advisability of a general treatment of water supplies with iodine. My doubt in the matter is not

[8] Engineer, Water Purification, Division of Water, Cleveland, Ohio.

[9] Chief, Water Laboratory, State Board of Health, Iowa City, Ia.

based upon the same sort of information that Mr. Ellms' doubt is based upon. It is a little different sort of material. Extensive experiments over in Switzerland have been made on the use of iodine as a goitre preventive. Switzerland is the State which is most interested, I take it, in the study of goitre prevention. They have had that problem for many years, and hospitals are filled with cretins, persons who are incapacitated in various ways, traceable to this disease among their progenitors. Naturally Switzerland has appointed a commission to study the use of iodides. There were some people on that commission who were afraid of the use of iodides, but they seemed to have been definitely in the minority. The point which interests me most in this connection, however, is the study which was written up into a paper on the treatment of girls from the age of 15 to 21. It is generally admitted that goitre incidence is highest among girls. In many of the papers I have read, that point has been emphasized. Now the point I want to make in this connection is that among these girls from 15 to 21 the effect of the iodide treatment was markedly less than in children of lower ages, and it is claimed that the effect of the iodides on those still older is even less, although iodine administered to expectant mothers is said to have a beneficial effect on their offspring.

Switzerland has been much interested in the preparation of iodized table salt. Of course, there are iodized table salts on the market in this country at the present time, especially in Michigan. Manufacturers keep in touch with the literature and the new fads, and so we have this iodized table salt on the market here. It is made by adding a small amount of sodium iodide to the salt. I believe the Swiss Federal Government was either to control the sale in Switzerland, subsidize it or perhaps they were to have a monopoly; I have forgotten which. This study I mentioned about the girls of the older ages in the public schools emphasized strongly that too much faith must not be placed in the use of iodized table salt by the entire population of the country because of the lessened effect of the dosage as applied to older people. The same thing would appear to me to apply to the iodine treatment of the drinking water; in other words, it is the iodine which is taken by the children which may be expected to be the effective part of the iodine. Its effect upon the older part of the population, therefore, if this is true, will be materially less, so that not only will you have your 98 per cent loss that Mr. Little has told us

about, but your effective iodine absorption will largely be limited to the ages, say, below 15. Now whether or not this is important from a financial standpoint, I shall not presume to say. It is certainly worth a good many dollars of the money of the people of Rochester to avoid developing goitre among the children of the city.

Rochester I think has an adequate system of medical inspection of schools. Perhaps I am not well informed on the matter, but I think they have. In some communities, such as Grand Rapids, chocolate candies, which contain a small dosage of iodine, sometimes as an iodide, sometimes as an organic iodine compound, have been administered, I believe through the agency of the medical inspectors of schools. Just how the cost of administering these chocolate candies to the school children would compare with the cost of the iodine treatment as applied by Mr. Little, I cannot say, but at any rate those chocolate candies contain a very minute dose of iodine and the children could eat a good many without taking in any material quantity of iodine. The candies have no medicinal taste and are eagerly eaten by the youngsters as I know from experience with my own boys. I found the candies were very palatable. It seems to me that the administration of candies such as this is a more direct way of getting the iodine to the youngster than the addition of the iodine to the drinking water. The important part of the administration of the iodine is therefore that which is given to the children and to expectant mothers. It may therefore be better to attempt a more direct administration of the iodine through the agency of the medical inspectors of the schools.

Mr. B. C. Little:[2] I find that I have to leave, but I should just like to answer one or two things that were spoken of. Mr. Ellms says it is doubtful if we do get the iodine after we put the sodium iodide into our water. He did not say just that, but as regards that, we do, we make tests before the sodium iodide is put in, while it is being put in and for some time after, and find that the iodine content does increase in the water when it is taken out of the tap in Rochester, just as we expected it to do. I do not know how it would be with waters that are chlorinated very strongly or with waters that are filtered, but it does take place all right in Rochester. Then as to Mr. Hinman's statements about the treatment of girls 15 to 18 or younger—it is not the idea at all to treat people who have goitre. We think perhaps it does help them, but that is not the idea, it is to

prevent their getting goitre. The only way we can do that is to give them this before they get the goitre, not to treat them after they get it. As he says, girls who have goitre, who are older, from 15 on, perhaps the taking of iodine will not help them very much, but we want to prevent goitre developing. I think it has been proven in Switzerland that it does stop goitre to a very great extent. They have tried this prophylactic treatment with table salt and the goitre reduction has been something like from 87 per cent in a great many children down to 13 per cent, but we cannot treat all those we should like with chocloate or table salt because we are not sure they will get it. Some of the schools are private schools and there are children who do not go to school. The ignorant you cannot get at through the schools, but they must take iodine if it is put into the water supply. We are ready to try something else when it is proven better or when this system has failed, but we want another year or two. I did not want to read this paper because we have not any results that we can give out fairly yet, but I hope perhaps in another year or so it will be better.

Mr. George C. Whipple:[10] This is a subject in which I am very much interested, but about which I know very little. Not knowing much, I have taken occasion to consult some of my medical friends whose names I do not feel at liberty to divulge, but they are almost all opposed to the idea of putting iodide into a public water supply. It certainly is not yet proved that simple goitre is merely a deficiency disease. That seems to be the prevailing idea at the present time, but when I was in Switzerland a few years ago, I took occasion to consult with some of the authorities there and found there was still a rather strong feeling that an infection is also involved. I was shown some interesting statistics at the University of Lausanne by young men who had been making a study of goitre in the various classes of the Swiss army. There seemed to be a rather strong correlation between the presence of goitre in certain cantons and the pollution of the water supplies in those same regions. That does not mean that the lack of iodine is not one contributing factor, but certainly we do not yet know all that there is to know about this disease. There is one thing that is certain, however, goitre is a very important disease.

[10] Consulting Engineer, Harvard University, Cambridge, Mass.

It seems to me that the author of the paper, Mr. Little, has made a good point in saying we ought to call this the iodide treatment and not the iodine treatment. Bacteriologists of the war department have recently recommended the use of iodine in place of chlorine for disinfecting water in army camps, and it seems to have a good deal of merit; therefore, we ought to keep the two processes quite separate in our thoughts. My chief objection to the use of iodide in water is a general one; I think there is a growing restlessness on the part of water consumers on account of the addition of various chemicals to water. We have already seen that in connection with the use of liquid chlorine and sometimes even in connection with the use of alum. I do not like to see the practice of treatment with poisonous chemicals carried too far, lest there be a reaction which will sweep away a good many things which we know are desirable. The experiment at Rochester is one to be watched with interest, but in my opinion there are other ways of giving iodine to those who need it which are less wasteful and more effective.

Dr. F. E. Hale:[11] I just want to speak on one point—the question of the policy of water treatment has been brought up in several of the discussions. When copper sulphate treatment first came in, there was a good deal of objection to it; people said we were adding poison to water. Let us not take that attitude. Let us treat each proposition on its own basis. When you add alum to water it reacts with the alkalinity and the alum is itself removed. When you add copper sulphate it is removed similarly, it settles in your reservoirs and stays there. The iodide treatment is a different problem. Recently in the last two or three years, the addition of sodium silicate to water has taken place to prevent corrosion, and other treatments are going to come. Let us not say that we do not want any more treatment of water, but consider each on its own basis as to its merits.

Mr. A. E. Gorman:[12] In the Rochester application of sodium iodide to water, they treated for two weeks in the spring and in the fall. I should like to ask why not put in relatively smaller dosages continuously throughout the year? You would certainly get away from the economic proposition of having a great demand for iodine at two

[11] Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y.
[12] Sanitary Engineer, Water Department, Chicago, Ill.

seasons of the year. In case all cities should adopt that system, the seasonal demand might be very great. Is it not possible that, since the iodine is put into the water only twice a year, much of the iodine might be lost, due to its lack of absorption by the human system in that short interval; whereas if you put in a relatively smaller amount continuously the system might absorb what it needs and not lose possibly half of the iodine that was taken in during the two weeks' period? When applying a relatively large amount within a two weeks' period, a considerable proportion might be lost in the urine, whereas continual absorption would keep the thyroid saturated.

Dr. Max Levine:[13] It seems that a great many physicians are opposed to the iodine treatment on the ground that they are not yet convinced that iodine deficiency is the cause of goitre, and that is a good fundamental objection from their standpoint. However, it is not always necessary to prove the cause in order to utilize an effective remedy. It is conceivable that iodine may be indirectly associated with the cause of goitre, although not the main cause. It is conceivable that goitre may be infectious and that iodine may have a considerable specific bactericidal action on those specific organisms. As my old teacher, Dr. Sedgwick, used to say, "the proof of the pudding is in the eating." If the administration of iodine eliminates goitre, it would be worth while employing it. Whether it is worth while adding it to the water supply is a matter to be considered on economic grounds.

I want to say another word in reference to the supposed poisonousness of iodine. There seems to be a general impression that iodine is a serious and violent poison. I had occasion a few years ago to look up the dose of iodine as given in the pharmacopoea. The dose given there was three drops as a maximum. Larger doses were thought poisonous. I have myself taken as much as 90 drops of ordinary tincture of iodine which I bought on the market, for a period of three months without any ill effects. It seems that iodine, even if administered in such large doses, is not retained by the body for any considerable time. Within 20 minutes after the administration of 30 drops of iodine, you can get a test for iodine in the sputum, within an hour you can get a test in the bladder discharges. A great many physicians are administering iodine in the form of tincture of iodine

[13] Associate Professor, Bacteriology, Iowa State College, Ames, Ia.

in tremendous doses up to as high as 180 drops a day in milk, in the treatment of tuberculosis and pus infections of various kinds, so that the idea that iodine is a serious poison has been very much over emphasized.

Mr. N. J. Howard:[14] If the theoretical considerations regarding the application of sodium iodide are taken into account, it would seem that the prohibition laws might be unconsciously aiding in the treatment of goitre by increasing the consumption of water. My impression was that the medical profession largely opposed the treatment of goitre through water, on account of the impracticability of administering a therapeutic dose. The city of Cleveland quite recently, within the last five years, made a very extensive survey of the school children there, and they found, the same as in New York State, that there was a great deficiency in the children examined. They followed it up by enabling the children, with their parents' consent, to take a ten-day treatment, ten days in the spring and ten days in the fall, with truly remarkable results. I believe something like 78 or 80 per cent of the children treated with sodium iodide, in correct therapeutic doses, derived great benefit. The amount of water which would have to be consumed in any community, particularly in those cases where water is treated only in the spring and in the fall, would be so great, and it would seem to me, even if the cost were very small, that the money would be absolutely wasted. Time alone will indicate whether the policy of Rochester will be justified, but at present the amount of iodine contained in three or four glasses of water that a child might drink in a day, would be so small that the therapeutic value will be nil.

Mr. W. W. Brush:[15] Mr. Little told me just before he left that in Rochester the normal iodine content of the water is less than 1 part per billion and that, while the treatment is going on, they have 50 parts per billion. In the New York City supply, and Dr. Hale can correct me if I am wrong, I believe our tests show that we have about 1½ parts per billion in other than the Long Island supply.

[14] Bacteriologist in Charge, Filtration Plant Laboratory, Toronto, Ont.

[15] Deputy Chief Engineer, Department Water Supply, Gas and Electricity, New York, N. Y.

Dr. F. E. Hale:[11] It is 1.1 parts per billion in the Catskill supply and 1.3 parts in the Croton supply and 2.1 parts in the Long Island supply, per billion. As to Rochester, that 50 parts per billion is the peak of the chart. For three weeks the curve goes up, and then down again, and the peak is 50 parts per billion.

Mr. William Gore:[16] I would like to ask Mr. Little what has become of the old correlation ideas between the Dolomite lime stone and goitre? It used to be considered in England that goitre was prevalent in the region of magnesium lime stone or dolomites. It is well known that in Switzerland the Swiss rocks are of the magnesium lime stone formation and that goitre is very prevalent there. I would like to ask Mr. Little what has thrown that idea into the discard.

Mr. C. F. Drake:[17] If Mr. Gore will take the Collins paper with a map of the United States showing the water supply and the total hardness of the water and follow it up with the map published by Dr. Crotti, of Columbus, in his new book on goitre and then follow for 10 years the United States census report showing the exophthalmic death rate, he will find that Oregon has the softest water in the country and the highest exophthalmic goitre rate in the country; in other words, we have been barking up the wrong tree. Let us get on the right track.

[16] Consulting Engineer, Toronto, Ontario.
[17] Division Superintendent, Pittsburgh Filtration Plant, Aspinwall, Pa.

WATER WORKS INFORMATION

By Frank C. Jordan[1]

The Indianapolis Water Company is under obligation to the members of the water works fraternity, who answered a questionnaire sent out by the Company on June 30, 1923. Certain of the information obtainable from the questionnaire has been tabulated and is transmitted for the attention of the members of this Association.

This information covers the water rates in 234 cities, assessments or frontage taxes for water main extensions, charges made for public fire protection service and other city uses by municipally operated water plants and trend towards the elimination of "free water." The data follow.

Water rates in 234 American cities

USES	AVERAGE RATES
Flat rate for water for 5-room modern house with bath, toilet, kitchen sink, wash-stand, laundry trays and sprinkling for 30′ lot	$20.52
Meter rate per 1000 gallons for first 7500 gallons used in one month by small consumers, such as residences, small stores, schools, etc.	0.238
Rate for the first million gallons used in one month by larger consumers, such as office buildings, hotels, factories, hospitals, etc.	121.47
Rate per million gallons for water used in excess of the first million gallons by large consumers, such as packing houses, factories, railroads, etc.	102.84

The supporting data follow.

[1]Secretary, Indianapolis Water Company, Indianapolis, Ind.

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7,500 gallons or less during month. Rate per 1,000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			cents		
Adrian, Mich.	City	Yes	32	$160.00	$160.00
Akron, Ohio	City	Yes	21	180.00	160.00
Albuquerque, N. M.	City	No			
Allentown, Penn.	City	No			
Amsterdam, N. Y.	City	No	$10\frac{2}{3}$	78.65	40.00
Anaconda, Mont.	City	Yes			
Ann Arbor, Mich.	City	No	16		80.00
Ashland, Wis.	Private	Yes	24	150.83	133.33
Atchison, Kans.	Private	Yes	35	130.45	100.00
Atlanta, Ga.	City	Yes	$13\frac{1}{2}$	103.83	93.20
Bangor, Me.	City	Yes	$33\frac{1}{3}$	95.00	66.64
Baltimore, Md.	City	Yes	$26\frac{2}{3}$	133.34	133.34
Battle Creek, Mich.	City	Yes			
Baton Rouge, La.	Private	No	35	100.00	100.00
Bay City, Mich.	City	Treated			
Bayonne, N. J.	City	Treated			
Bedford, Mass.	City	No	30		
Billings, Mont.	City	Yes	$33\frac{1}{3}$	112.00	66.67
Binghampton, N. Y.	City	Yes	10		60.00
Birmingham, Ala.					
Bridgeport, Conn.	Private		18	192.45	80.00
Bristol, Conn.	City		24	136.31	86.67
Brockton, Mass.	City	No	$25\frac{1}{3}$	137.83	133.32
Brunswick, Me.	City	No	$33\frac{1}{3}$	104.00	80.00
Burlington, Iowa	City	Yes	30	105.25	100.00
Butte, Mont.	Private	Treated	46	200.00	173.33
Cairo, Ill.	Private	Yes			
Camden, N. J.	City	No	25	100.00	100.00
Canton, Ohio	City	No	$10\frac{2}{3}$	86.00	80.00
Cedar Rapids, Iowa	City		$24\frac{2}{3}$	109.33	93.33
Champaign, Ill.	Private	Treated	33		79.20
Charleston, S. C.	City	Yes	$24\frac{2}{3}$	175.80	
Chelsa, Mass.	City	No	14.7	147.00	147.00
Chester, Penn.	Private	Yes	$34\frac{1}{2}$		115.00
Chicago, Ill.	City	Treated	$8\frac{1}{3}$		83.33

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month.
			cents		
Clarksburg, W. Va...........	City	Yes	$34\frac{2}{3}$	$168.30	$150.00
Cincinnati, Ohio.............	City	Yes	16	160.00	160.00
Cleveland, Ohio.............	City	Yes	8	80.00	80.00
Colorado Spr., Col...........	City	No	15	81.55	80.00
Columbia, S. C..............	City	Yes	20	126.00	126.00
Columbus, Ohio..............	City	Yes	16	153.33	146.66
Concord, Mass...............	City	No	$26\frac{2}{3}$	119.00	100.00
Concord, N. H...............	City	No	22	104.53	50.00
Council Bluffs, Iowa.........	City	Yes	35	112.50	100.00
Covington, Ky...............	City	Yes	24	130.00	126.66
Dallas, Texas,...............	City	Yes	30	203.50	200.00
Davenport, Iowa............	Private	Yes	35	114.80	110.00
Dayton, Ohio................	City	Treated	$15\frac{1}{3}$	71.75	60.00
Daytona, Fla................	City	Treated	10	100.00	100.00
Decatur, Ill..................	City	Treated	50	107.33	70.00
Delaware, Ohio..............	Private	Yes	$49\frac{1}{3}$		146.66
Denver, Colo................	City	Yes	17	100.00	80.00
Des Moines, Iowa............	City	Treated	30		100.00
Detroit, Mich................	City	Treated	$8\frac{2}{3}$		53.33
Dover, N. H.................	City	Treated			
Dubuque, Iowa.............	City	Treated	$33\frac{1}{3}$	120.43	80.00
Duquesna, Penn.............	City	No			
Duluth, Minn................	City	Treated	20		100.66
Durham, N. C...............	City		30	190.00	180.00
Elmira, N. Y................	City	Yes	40	99.16	80.00
El Paso, Tex................	City	No			
Erie, Penn...................	City	Yes			
Everett, Mass...............	City	Yes	$13\frac{1}{3}$	121.34	80.54
Fall River, Mass.............	City	No	32	160.00	140.00
Fitchburg, Mass.............	City	No	24		60.67
Flint, Mich..................	City	Yes	20	110.17	106.66
Framingham, Mass...........	City	Yes	$33\frac{1}{3}$	120.00	120.00
Frankfort, Ky...............	Private	Yes	31		60.00
Fremont, Ohio...............	City	No	12	75.30	60.00
Fresno, Cal.................	Private	No			

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			cents		
Galveston, Tex.	City	No			
Gardner, Mass.	City		$33\frac{1}{3}$	$200.00	$200.00
Geneva, N. Y.	City	Yes	$33\frac{1}{3}$	80.00	80.00
Gloversville, N. Y.	City	Treated	16		46.66
Grand Rapids, Mich.	City	Yes	$9\frac{1}{3}$	93.33	93.33
Grand Forks, N. D.	City	Yes	40	56.55	150.00
Guthrie, Okla.	City	Yes			
Hagerstown, Md.	City	Treated	27	93.19	80.00
Hamilton, Ohio	City	No			
Hartford, Conn.	City	Yes	16	134.00	80.00
Haverill, Mass.	City	No	$21\frac{1}{3}$	100.00	100.00
Holyoke, Mass.	City	No	$5\frac{2}{3}$	56.66	56.66
Houston, Tex.	City	No	15	140.00	140.00
Hutchinson, Kans.	Private	Treated	30	110.00	100.00
Independence, Mo.	Private	Filtered	35	162.15	120.00
Ishpeming, Mich.	City	Treated	12		50.00
Jackson, Mich.	City	Treated	12	90.00	90.00
Jackson, Miss.	City	Yes	$26\frac{2}{3}$	135.33	133.33
Jackson, Tenn.	City	No	18	96.00	90.00
Jacksonville, Fla.	City				
Jamestown, N. Y.	City	No	$26\frac{2}{3}$	266.66	266.66
Jersey City, N. J.	City	Treated	12	120.00	
Joseph, Mo.	Private	Filtered	35	115.00	80.00
Kalamazoo, Mich.	City	No			
Kansas City, Kans.	City	Treated	$22\frac{2}{3}$	122.13	80.00
Kansas City, Mo.	City	Filtered	$22\frac{2}{3}$	122.13	91.47
Kenosha, Wis.	City	Treated	16	102.33	60.00
Keokuk, Iowa	Private	Filtered	58	147.56	131.00
Kitchener, Ont.	City	No	$15\frac{1}{2}$	133.33	80.00
La Crosse, Wis.	City	No	20	100.00	81.00
Lancaster, Penn.	City	Filtered	5	50.00	50.00
Lansing, Mich.	City	Treated	16	76.24	64.00
Lawrence, Mass.	City		20	200.00	200.00
Lawrence, Kans.	City	Treated	$38\frac{1}{4}$		
Lebanon, Penn.	City	Treated	$27\frac{2}{3}$	55.48	45.00

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			cents		
Lexington, Ky	Private		25	$129.25	$90.00
Lincoln, Neb	City	Treated			
Lockport, N. Y	City	Treated	10	31.30	30.00
London, Ont	City	Filtered	16	113.75	106.67
Lorain, Ohio	City	Filtered	$26\frac{2}{3}$	133.80	120.00
Los Angeles, Cal	City		$13\frac{1}{3}$	95.67	66.66
Louisville, Ky	City	Filtered	15	62.25	60.00
Lowell, Mass	City	Filtered	28	280.00	280.00
Ludington, Mich	City	Treated			
Lynchburg, Va	City	Filtered	24	106.40	80.00
Lynn, Mass	City	No	21	165.08	106.66
Macon, Ga	City	Filtered	25	110.00	60.00
Madison, Wis	City				
Manchester, Conn	Private	Treated			
Manchester, Vt	Private		30	100.00	100.00
Marion, Ohio	Private		25		
Marquette, Mich	City	Treated	$13\frac{1}{3}$	43.03	40.00
Massillon, Ohio	Private	No	$29\frac{1}{3}$	153.77	146.66
Meridan, Conn	City	Treated	15	100.00	100.00
Meridian, Miss	City	Filtered	30	105.50	60.00
Miami, Fla	Private	Treated	$21\frac{1}{3}$	146.66	106.66
Middletown, Ohio	City	No			
Milwaukee, Wis	City	Treated	$9\frac{1}{3}$	93.33	93.33
Minneapolis, Minn	City	Filtered	8	80.00	80.00
Missoula, Montana	Private	Treated	$34\frac{2}{3}$	116.50	66.67
Mobile, Ala	City	Treated	15	100.00	100.00
Montgomery, Ala	City	No			
Mt. Clemens, Mich	City	No	20	148.27	146.66
Muscatine, Iowa	City	No	$33\frac{1}{3}$	78.75	66.66
Nashville, Tenn	City	Treated	$18\frac{1}{3}$	105.00	80.00
National City, Cal	Private	Treated			
New Bedford, Mass	City	No	15	100.00	100.00
New Britain, Conn	City	Treated	$13\frac{1}{3}$	133.33	133.33
Newburyport, Mass	City	Filtered	$25\frac{1}{3}$	140.00	140.00
New Haven, Conn	Private	Treated	18	100.00	100.00

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATE		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			cents		
New Orleans, La.	City	Filtered			
New Rochelle, N. Y.	Private	Treated	40	$283.33	$266.67
New York City, N. Y.	City	Treated	13⅓	133.33	133.33
Niagara Falls, N. Y.	City	Filtered	10⅔	40.00	40.00
Norfolk, Va.	City	Filtered	22	106.00	80.00
Norwalk, Conn.	City		25	55.50	50.00
Norwich, Conn.	City	Treated			
Oakland, Cal.	Private	Filtered	30⅔	273.33	253.33
Ogdensburg, N. Y.	City	Filtered			
Oklahoma City, Okla.	City	Treated	18	134.00	90.00
Olean, N. Y.	City	Filtered	20⅔	86.66	86.66
Omaha, Neb.	City	Filtered	16⅔	100.00	80.00
Ottumwa, Iowa	City	Treated	25	100.00	65.00
Owensboro, Ky.	City	Treated	37½	83.60	80.00
Paterson, N. J.	Private	Filtered	30	104.50	100.00
Pawtucket, R. I.	City	Treated	30		
Peekskill, N. Y.	City	Filtered	21⅓	160.00	160.00
Pekin, Ill.					
Pensacola, Fla.	City	No	30	138.50	125.00
Peoria, Ill.	Private	No	36½	83.14	52.00
Phillipsburg, N, J.	Private	No	35	118.33	66.66
Pine Bluff, Ark.,	Private	Treated	46	182.00	150.00
Pittsburg, Kans.	City	No			
Pomona, Cal.	Private		26⅔	110.67	106.66
Port Huron, Mich.	City	Treated	10	41.25	20.00
Portland, Ore.	City	No	10⅔	84.00	80.00
Providence, R. I.	City		20	187.50	100.00
Quincy, Ill.	City	Filtered	45	149.18	80.00
Racine, Wis.			26⅔	111.57	66.40
Raleigh, N. C.	City	Treated	30	157.50	120.00
Reading, Penn.	City	Filtered	10⅔	106.67	106.67
Rensselaer, N. Y.	Private	Treated	33⅓	128.00	120.00
Roanoke, Va.	Private	Treated	30	127.80	70.00
Rochester, N. Y.	City	No	18	158.00	140.00
Sacramento, Cal.	City				

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			cents		
San Antonio, Tex.	Private	No	20	\$77.04	\$72.00
San Francisco, Cal.	Private	No	$38\frac{4}{10}$	301.17	288.00
Savannah, Ga.	City	No	12	81.80	60.00
Schenectady, N. Y.	City	No			
Seattle, Wash.	City	Treated	$10\frac{2}{3}$	59.33	53.33
Sedalia, Mo.	Private	Filtered	35	167.50	100.00
Seneca Falls, N. Y	Private	Filtered	$26\frac{2}{3}$	136.33	133.33
Sharon, Penn.	Private	Filtered	$30\frac{2}{3}$	146.66	146.66
Sioux City, Iowa,	City	No	25	107.10	100.00
Somerville, Mass.	City	Treated			
Spokane, Wash.	City	No	10	100.00	50.00
Springfield, Mass.	City	Treated	$29\frac{1}{3}$	69.50	66.66
St. Catharines, Ont.	City	Treated			
St. Joseph, Mo.	Private	Filtered			
St. Louis, Mo.	City	Filtered	$19\frac{1}{3}$	103.98	80.00
St. Paul, Minn.	City	Treated	8	80.00	80.00
Streator, Ill.	Private	Treated	32		
Superior, Wis.	Private	Filtered	$36\frac{8}{10}$	80.00	80.00
Tacoma, Wash.	City	Treated	20	53.33	53.33
Tampa, Fla.	City		$22\frac{2}{3}$	136.50	120.00
Taunton, Mass.	City	No	20	100.00	95.00
Tiffin, Ohio	Private	Filtered	$53\frac{1}{3}$	243.13	213.33
Toledo, Ohio	City	Filtered	$13\frac{1}{3}$	121.00	66.66
Topeka, Kans.	City	Filtered			
Toronto, Can.	City		$13\frac{3}{4}$		
Tucson, Ariz.	City		$16\frac{2}{3}$	100.00	100.00
Victoria, B. C.	City	No			
Waco, Tex.			26	60.00	60.00
Walla Walla, Wash.	City	Treated	$24\frac{1}{2}$	80.00	80.00
Walkerville, Can.	Private	Treated	$8\frac{1}{3}$	65.73	63.33
Waltham, Mass.	City	No	$26\frac{2}{3}$	148.46	146.66
Warren, Ohio	City				
Waterbury, Conn.	City	Treated	$20\frac{2}{3}$	160.00	160.00
Waterford, N. Y.	City	Filtered	30	120.00	120.00
Watertown, N. Y.	City	Filtered	20	30.00	30.00

NAME OF CITY	OWNERSHIP OF PLANT	IS WATER FILTERED	METERED WATER RATES		
			Consumption, 7500 gallons or less during month. Rate per 1000 gallons	Large consumers	
				Rate for first million gallons used during one month	Rate per million gallons for water used in excess of first million gallons in month
			cents		
Wellesley, Mass.	City	No	25	$250.00	$250.00
West Orange, N. J.	Private	No			
Wilkinsburg, Penn.	Private		$28\frac{4}{10}$	164.26	120.00
Williamsport, Penn.	Private	Treated	33	103.20	50.00
Wilmington, Del.	City	Filtered	10	73.52	73.33
Wilmington, N. C.	City	Filtered	24	128.00	128.00
Winnipeg, Can.	City	Treated			
Winthrop, Mass.	City	Treated	20	200.00	200.00
Worcester, Mass.	City		20	100.00	100.00
Yakima, Wash.	Private	Treated	$25\frac{1}{3}$	80.56	74.00
Yonkers, N. Y.	City	Treated	$13\frac{1}{3}$	133.33	133.33
York, Penn.	Private	Filtered	50	106.80	85.00
Youngstown, Ohio	City	Filtered	$26\frac{2}{3}$	113.16	106.66

Many cities have adopted the policy of levying assessments or frontage taxes to cover a portion or all of the cost of water main extensions. This procedure is followed by municipally owned plants only, all water main extensions in privately owned plants being financed by the water company.

The following are typical cases of interest:

Cincinnati, Ohio: The property owner pays the cost of the mains in front of his property

Washington, D. C.: Abutting property is assessed $2.00 per front foot.

Tacoma, Wash.: The property owner is assessed on basis of a 6-inch main.

Seattle, Wash.: Property assessed for cost of mains, payable in 10 installments. Approximate cost $2.00 to $2.25 per linear foot of property.

Reading, Pa.: This property is assessed $1.00 per front foot on each side of street

St. Paul, Minn.: Frontage tax of 10 cents per year for 10 years, on each side of street

Racine, Wis.: Property owner pays cost of water main up to 6-inch

Milwaukee, Wis.: Property is assessed on basis of cost of a 6-inch main

Minneapolis, Minn.: Property is assessed on basis of a 6-inch main

Philadelphia, Penn.: Property on both sides of street assessed $2.00 per front foot

Omaha, Neb.: Property is assessed on basis of actual cost of installation, not to exceed the cost of a 6-inch main

Detroit, Mich.: Assessment of 50 cents per foot of frontage served

Harrisburg, Penn.: Assessment for 6-inch, 80 cents per front foot; 8-inch, 90 cents; 10-inch, $1.00

Hartford, Conn.: Assessment for one-half cost of 6-inch main

Kenosha, Wis.: Assessment 80 cents per front foot, on each side of street, or $1.60 per foot of pipe

Kitchener, Ont.: Actual cost of main

Madison, Wis.: One-half cost of main. Average assessment $1.00 per foot

Middletown, Ohio: Assessment of one-half cost of main

Lockport, N. Y.: Assessment of property benefited

Lincoln, Neb.: Cost of main assessed against property benefited

Grand Forks, N. D.: Assessment against abutting property for entire cost of main

Lake Forest, Ill.: Special assessment

Decatur, Ill.: Special assessment against property benefited

Elgin, Ill.: Special assessment against property benefited

Springfield, Ill.: Entire cost of main assessed to abutting property

Allentown, Penn.: Assessment of $1.20 per front foot on each side of street for 6-inch pipe; 8-inch, $1.50; 12-inch, $2.25

Cleveland, Ohio: Mains laid by private contract under supervision of water board or by taxation plan. Maximum charge $2.00 per foot on taxable property

Albany, N. Y.: Special assessment

Xenia, Ohio: Special assessment

Ann Arbor, Mich.: $1.00 per running foot

Los Angeles, Cal.: 80 cents per front foot of property to be served, provided required extension does not exceed 200 feet. Extensions in excess of 200 feet, $1.60 per foot

Louisville, Ky.: Small distribution mains paid for jointly by the Louisville Water Co. and the prospective consumers

New Britain, Conn.: Annual assessment of 10 per cent of cost of main for 10 years

Port Huron, Mich.: 30 cents per linear foot of frontage on each side of street

Many of the municipally owned water plants receive revenue from the city budget for public fire protection service and water for city uses, but pay no city taxes.

The following are typical cases:

Rochester, N. Y.: $126,000.00 per year for city water and fire protection

Portland, Ore.: $75,000.00 for city water

Omaha, Neb.: $180,000.00 for fire service

Oklahoma, City, Okla.: $70.00 per hydrant per annum

Des Moines, Iowa: Annual revenue of $350.00 per mile of pipe

Duluth, Minn.: $50.00 per annum for each hydrant
Durham, N. C.: $60.00 per annum for each hydrant
Ft. Scott, Kans.: $30.00 per annum for each hydrant
Flint, Mich.: $50.00 per year per hydrant
El Paso, Tex.: $64.50 per year per hydrant
Kenosha, Wis.: $39,000.00 per annum for fire service
Kansas City, Kans.: $35.00 per year for each hydrant
Kalamazoo, Mich.: $30.00 per year for each hydrant
Jamestown, N. Y.: $40.00 per year for each hydrant
Grand Rapids, Mich.: $35.00 per year for each hydrant
Amsterdam. N. Y.: $70,000.00 per annum for fire service through 850 hydrants
Ann Arbor, Mich.: $24,000.00 per year for fire service. 330 hydrants
Billings, Mont.: $30.00 per year for each hydrant
Brunswick, Me.: $30.00 per hydrant per annum
Charlestown, S. C.: $45,000.00 per year. 662 hydrants
Dallas, Tex.: $36.00 per year per hydrant
Denver, Colo.: $22.50 per hydrant for fire service and city uses
Concord. Mass.: $12,000.00 per year. 252 hydrants
Bay City, Mich.: $75,000.00 per year. 1215 hydrants
Bangor, Me.: $30.00 per hydrant per annum
Bristol, Conn.: 1-way hydrant—$12.00 per year. 2-way hydrant—$15.00 per year. 3-way hydrant—$18.00 per year
Lansing, Mich.: $35.00 per year per hydrant
London, Ont., Can.: $17,000.00 per year. 1000 hydrants
Madison, Wis.: $50,000.00 per year for fire service and city uses
Marion, Ohio: $27.50 per hydrant per year
Marquette, Mich.: $25.00 per hydrant per year
Missoula, Mont.: $60.00 per hydrant per year
Racine, Wis.: $25.00 per hydrant per year
Sedalia, Mo.: $13,500.00 per annum. 253 hydrants
Toronto, Can.: $964,818.00 for fire service through 7190 hydrants
Topeka, Kans.: $62.50 per annum for each hydrant
Walkerville, Ont.: $30.00 per annum on all hydrants installed by city
Framingham, Mass.: $27.50 per annum for each hydrant
Norwalk, Conn.: $15.00 per annum for each hydrant
Niagara Falls, N. Y.: $25.00 per annum for each hydrant
Macon, Ga.: $30.00 per annum for each hydrant
Ludington, Mich.: $9,000.00 per annum for 230 hydrants
Lynchburg, Va.: $18,000.00 per annum for 506 hydrants
Daytona, Fla.: $7,000.00 per annum for 91 hydrants
Holland, Mich.: $40.00 per annum for each hydrant
Jacksonville, Fla.: $28,000.00 per annum for fire service through 991 hydrants
Kitchener, Ont.: $35.00 per annum per hydrant
Lake Forest, Ill.: $9,200.00 per annum for 186 hydrants
Winnipeg, Man., Can.: $30.00 per annum for each hydrant
Victoria, B. C.: $18.00 per annum per hydrant
St. Catherines, Ont.: $20.00 per annum per hydrant
St. Paul, Minn.: $14.00 per annum per hydrant

Waco, Tex.: $12.50 per annum per hydrant
Gardner, Mass.: $12,000.00 per annum for fire service and city uses
Spokane, Wash.: $18,000.00 per annum for fire service
Pawtucket, R. I.: $10.00 for each 1-way hydrant. $20.00 for each 2-way hydrant, $40.00 for each 4-way hydrant
Adrian, Mich.: $100.00 per annum for each hydrant
Bedford, Mass.: $20.00 per annum for each hydrant
Elmira, N. Y.: $6,000.00 per annum
Hartford, Conn.: Fire department pays for installation and upkeep of hydrants
Milwaukee, Wis.: $10.00 per annum for each hydrant
Newburyport, Mass.: $5,000.00 for fire service
Seattle, Wash.: $12.00 per annum for each hydrant
Tacoma, Wash.: $78,000.00 per annum
Wellesley, Mass.: $4,100.00 per annum
Wilmington, N. C.: $40.00 per hydrant per annum
Winthrop, Mass.: $3,000.00 per annum for hydrant maintenance

There is a growing tendency towards the elimination of so called "Free Water Service" as is evidenced by the following list of water companies or departments which furnish no "Free Service."

Oakland, Cal................Private Company
Cheyenne, Wyo................Private Company
Anaconda, Mont................Private Company
Ann Arbor, Mich..............Municipal
Ashland, Wis.................Municipal
Atchison, Kans...............Private (flushing sewers only, very small)
Bangor, Me...................Municipal
Bay City, Mich...............Municipal
Bedford, Mass................Municipal
Beloit, Wis..................Municipal
Billings, Mont...............Municipal
Boulder, Colo................Municipal
Bridgeport, Conn.............Private (water troughs only)
Bristol, Conn................Municipal
Brockton, Mass...............Municipal
Brunswick, Me................Municipal
Chelsea, Mass................Municipal
Chester, Penn................Private
Dallas, Tex..................Municipal
Davenport, Iowa..............Private
Delaware, Ohio...............Private
Denver, Colo.................Municipal
Des Moines, Iowa.............Municipal
Dover, N.H...................Municipal
Duluth, Minn.................Municipal
Durham, N. C.................Municipal
El Paso, Tex.................Municipal

Everitt, Mass.................Municipal
Flint, Mich...................Municipal
Framingham, Mass............Municipal (for drinking fountains only)
Frankfort, Ky................Private
Fresno, Cal...................Municipal
Gardner, Mass................Municipal
Grand Rapids, Mich..........Municipal
Hamilton, Ohio...............Municipal
Hartford, Conn...............Municipal (park fountains only)
Holland, Mich................Municipal
Holyoke, Mass................Municipal
Hutchinson, Kans............Private
Jackson, Mich.................Municipal
Jacksonville, Fla.............Municipal
Jamestown, N. Y.............Municipal
Kansas City, Kans...........Municipal
Kenosha, Wis.................Municipal
Keokuk, Iowa.................Private
Kitchener, Ont...............Municipal
Lake Charles, La.............Private
Lansing, Mich................Municipal
Lawrence, Mass..............Municipal
London, Ont...................Municipal
Lowell, Mass..................Municipal
Ludington, Mich.............Municipal
Lynchburg, Va................Municipal
Madison, Wis..................Municipal
Manchester, Vt...............Private
Meriden, Conn................Municipal (fire houses only)
Milwaukee, Wis..............Municipal
National City, Cal...........Private
New Rochelle, N. Y..........Municipal
Niagara Falls, N. Y..........Municipal
Norfolk, Va....................Municipal
Paterson, N. J.,...............Private
Pawtucket, R. I...............Municipal
Pomona, Cal...................Private
Racine, Wis....................Municipal
Rensselaer, N. Y.............Private
Roanoke, Va...................(3 drinking fountains only)
Rochester, N. Y..............Municipal
San Francisco, Cal...........Private
Seattle, Wash.................Municipal
Sedalia, Mo....................Municipal
Seneca Falls, N. Y...........Municipal
Sharon, Penn..................Private
Spokane, Wash...............Municipal
St. Catharines, Ont..........Municipal

St. Paul, Minn................Municipal
Streator, Ill..................Private
Tampa, Fla...................Municipal
Tiffen, Ohio...................Private
Toronto, Can.................Municipal
Victoria, B. C................Municipal
Waco, Texas.................Municipal
Walla Walla, Wash...........Municipal
Waltham, Mass...............Municipal (drinking fountains only)
Wellesley, Mass..............Municipal
West Orange, N. J............Private
Wilkinsburg, Penn............Private
Williamsport, Penn...........Private
Winnipeg, Can...............Municipal
Winthrop, Mass..............Municipal
Brazil, Ind....................Municipal
Lafayette, Ind................Municipal
New Castle, Ind..............Municipal
Richmond, Ind................Private
South Bend, Ind..............Municipal
Terre Haute, Ind.............Private
Vincennes, Ind...............Private
Washington, Ind..............Private (drinking fountains only)

DEVELOPMENT OF WATER PURIFICATION[1]

By George W. Fuller[2]

Water purification by means of sand filtration was first established in London ninety-five years ago. In those days it was the purpose to get clean water acceptable to sight and smell. That viewpoint prevailed for some fifty years and filtration was adopted at many important European cities.

The first guide-post along the road to progress in America came from the thorough-going investigations of European filtration practice by the late J. P. Kirkwood, for many years chief engineer of the Brooklyn Water Works, who was especially commissioned to make this investigation for the city of St. Louis. His published report was a classic on this subject and was translated into several foreign languages. The excessive muddiness of the Mississippi River at St. Louis, compared with the waters of Western Europe, was such that St. Louis did not adopt filters. The only immediate outcome on this side of the Atlantic of those splendid investigations was the building of two filter plants some fifty years ago by Mr. Kirkwood at Poughkeepsie and Hudson, N. Y. Each derived its supply from the Hudson River and the city of Poughkeepsie still continues this method with more or less modifications during recent years.

In the middle 'eighties, two important events occurred in relation to the quality of public water supplies. The principal one was the recognition by the leading sanitarians of the germ theory of disease. The second was the establishment of laboratory methods based on the new science of bacteriology. Water examinations quickly took on a new aspect as compared with earlier records comprising chemical tests only. In a short time numerous investigations were under way to record the bacterial removal by various purification processes, operating under different conditions as to rates of filtra-

[1] Abstract of paper read at Convention of Canadian Section. Complete paper in Canadian Engineer, March 11, 1924.

[2] Consulting Engineer, New York, N. Y.

tion, thickness of sand bed, size of sand and other items dealing with the economics of the situation.

Those were the days when terrific epidemics of typhoid fever and other water-borne diseases were of frequent occurrence on this side of the Atlantic. Death rates from 25 to 100 times as great as now found in dozens of cities were by no means unusual.

In 1892 a severe outbreak of Asiatic cholera occurred in Hamburg and through shipping channels was spread to various ports including vessels held in quarantine in New York Harbor. This danger stimulated activities at numerous places in respect to water filtration. Particularly so because of the fact that while Hamburg, deriving its water supply from the River Elbe, suffered so severely from cholera, its neighboring city of Altoona, enjoyed a substantial immunity, although its supply prior to its purification by filtration came from the same polluted river.

The Massachusetts State Board of Health at that date had been investigating for several years the engineering, chemical and biological aspects of various means of purifying water and sewage. Knowledge of the efficiency of filters in removing disease germs, coupled with a potential danger from cholera then in New York Harbor, led to prompt action on the part of the late H. F. Mills, engineer member of the State Board. The result was that the typhoid-fever-scourged city of Lawrence, Mass., installed a sand filter with commendable promptness. A few years later the city of Albany installed filters for the purification of its polluted supply from the Hudson River, taken from an intake only a short distance below Troy.

Investigations at Louisville, Cincinnati and Pittsburgh with rapid filters, embodying the use of coagulants and sedimentation in relatively large basins, brought forth a program which allowed satisfactory solution of water purification problems for those cities deriving their supply from muddy rivers. Beginning with the Little Falls plant of the East Jersey Water Company, which has supplied a dozen or more cities in northern New Jersey since 1902, the so-called mechanical or rapid sand filter has been adopted at hundreds of cities and towns in America with hygienic results which have been very satisfactory.

About fifteen years ago it was found that a large proportion of the objectionable bacteria in water might be eliminated by chlorine. This process has been adopted very generally in America as one

means of purifying water. In some instances its use is the sole method of treatment while in other cases its use is in conjunction with filtration, either to serve as a factor of safety, hygienically, or with the purpose of permitting economies as compared with filtration practice of earlier years. Chlorination is a very helpful procedure, but too much has been expected of it in many places. Its efficiency depends upon having the right quantity of chlorine present in all of the water to be treated and upon this result prevailing during each of the 1440 minutes per day. The difficulties are that in some instances there are periods when insufficient chlorine actually reaches the water to destroy objectionable bacteria, while there are other instances where there is an over dose with corresponding complaints as to tastes and odors. The presence of trade wastes in some supplies has also limited the usefulness of chlorination.

When chlorination is practiced in conjunction with filtration the required quantities of chlorine are less than for unfiltered water. This and advance in the art of its application cause it to become rightfully a useful factor of safety in conjunction with filtration plants.

These comments touch upon a few of the more important developments of the past century in the field of water purification. They deal with a subject that is both old and new. It is old in that it deals with a branch of municipal sanitation which by experience has demonstrated its importance for nearly one hundred years. The subject is new in the sense that the art of water purification is moving forward steadily and in a technical sense is perhaps engaging more attention now than it did a dozen years ago, in respect to getting reliable results under a great range of varying conditions from local supplies and with due regard to the economics of the problem.

A few years ago the typhoid toll in America was a substantial burden upon our population in that annually there were over 20,000 lives lost from typhoid fever with 10 to 20 times as many more suffering from the disease. Economically this meant great waste. This has been variously estimated at from $5,000 to $10,000 per single death, indicating that the total annual loss would reach figures of $150,000,000 or more.

Statistics by the Department of Commerce covering the entire registration area show a reduction in the typhoid death rate from 35.9 in 1900 to 7.5 per 100,000 in 1922.

In speaking on this subject here in Hamilton, I am reminded that in this city it is well to call attention to several different items, as follows:

This city, which derives its water supply from Lake Ontario and furnishes it to citizens without any purification, by either chlorination or filtration, is one of the few large cities on or near the Great Lakes which has not adopted any means for water purification or taken steps toward that end.

While Hamilton has enjoyed the benefits of protection from its own sewage flow in a degree not found at some cities elsewhere, yet its use of an unfiltered Lake supply is a custom which is at variance with the best practice as found elsewhere.

Perhaps some mention should be made of the fact that in the Great Lakes basin attention has recently been given to the fact that at Rochester, N. Y., the custom was adopted quite recently of adding an iodine salt directly to the water supply to correct deficiency of this element. Its purpose is to lessen the prevalence of common goitre and it is said that the results are gratifying, although convincing data are not yet available.

In conclusion let me state that I recognize that the last thirty years have seen great progress in many branches of municipal sanitation. Several of them are related to the reduction of typhoid fever death rates, such as improved milk supplies and vaccination against typhoid. But none of them are of more importance than the elimination of polluted water supplies as delivered to the citizens. Purification methods have been of enormous aid in bringing about those improvements. Not only is there available the filter plant, but also chlorination. Furthermore double filtration is available as practiced at Albany and Poughkeepsie and several places abroad. No longer can it be said that means are not at hand for treating water supplies adequately and economically, as gross revenues of water departments providing filtered water seldom exceed one and a half or two cents per person daily.

SEDIMENTATION IN THE PURIFICATION OF WATER AT CEDAR RAPIDS, IOWA[1]

By C. O. Bates[2]

A matter of first importance in the process of water purification in the Cedar Rapids Plant has been the introduction of a settling basin. The basin was rather hastily improvised to relieve an approaching condition which was proving serious. The demand for water had been constantly increasing while there had been a constant deterioration of the plant due to all over-worked parts. While at the same time there had been for a third of a century an increase in the pollution of the river where we get nearly all of our water. This increase of pollution is evidenced by the increase of chlorin as chlorides. Thirty years ago the chlorin was a very little more than three parts per million, today it is nearly ten parts per million. This may be accounted for by the increase in population in the Cedar River's drainage basin, but more particularly by the greater number of homes that have made sanitary sewer connections. Industrial wastes have also added a certain amount of pollution.

Forty-seven years ago when the water plant was built the water was taken from the Cedar River and pumped directly into the city mains without treatment. The city was supplied with water for about seven years by this method. Three artesian wells were then drilled and put into use which supplied the city with water satisfactory for all except industrial purposes. This condition lasted five years. The wells then began to fail. This, together with increased demand for water, on account of increased growth of the city, was the cause of the greater part of our water being brought from the river.

The question of a settling basin has been a matter for consideration from time to time for the past thirty-five years, but there is absolutely no surface space for such a basin in the vicinity of the water plant. The difficulty for the present has been fairly well met by building a wooden structure of one quarter of a million gallons

[1] Presented before the Iowa Section Meeting, November 2, 1922.

[2] Professor, Department of Chemistry, Coe College, Cedar Rapids, Iowa.

capacity, 12 feet above the ground level, covering it completely and screening it at all points where the air has access. The basin was designed and constructed by Superintendent H. F. Blomquist.

It is divided into two sections each of which is about 85 feet long and 25 feet wide, and are connected by a flume which permits the water to pass from one section to the other. Each section is divided into two channels. The water enters the west section on the north side from the river, passes down the channel, which is $12\frac{1}{2}$ feet wide and 8 feet deep, the entire length of the section, curves around into the channel on the south side, returns the length of the section and passes through the flume to the east section, where it traverses the entire length of the section twice, completing in its entire circuit a distance of 340 feet and passes over 5 transverse baffles. The time the water is in the basin is about one and five-tenths hours.

The water, coming from the river, receives the alum just before it enters the pump which forces it up into the basin. The journey through the pipes from the pumps to the basin is about 200 feet. On entering the basin the water is given a whirling motion by turbine-like vanes as it is released. This whirling motion completes the thorough mixing of the alum with the water. The floc just begins to form as it enters the basin and a visible increase is noticed throughout the entire journey in the basin, being very conspicuous where it leaves for the filters. It is, however, broken up into fine particles in passing through the pipes to the filters.

WHAT THE BASIN HAS ACCOMPLISHED

The basin was installed in active service February 3, 1922. During the first sixty-eight days of service there was accumulated in the bottom of the tank 400 tons of sediment, approximately three hundred million gallons of water having passed through the basin. This makes an average of 6 tons per twenty-four hours of sediment retained by the basin.

The basin was thoroughly washed on May 6 and 7 and was run for one hundred and thirty-seven days before a second cleaning on September 20. During this period a skimmer was installed in each basin, which carries off all the sediment that rises to the surface of the water, and transfers it to sewer pipes. The amount accumulated during the summer averaged somewhat less than during the spring months. The average was $4\frac{1}{2}$ tons per twenty-four hours, amounting to 650 tons during the one hundred and

thirty-seven days. The average during the spring and summer was a little over five tons per day. This has been a great relief to the filters. In fact, it would have been impossible to have given the city satisfactory water during the spring and summer months of this year without this basin.

The sediment was an average taken from number of places in the basin. After making a determination of the average sample as to total weight of sediment in both spring and summer determinations, an average sample of the sediment was reduced to a dry powder, and found to be four-fifths water and one-fifth solid matter.

Our conditions would be improved especially as to taste and odor, if we had another basin of size equal to the present one. This would help us to take care of the water during the flood season. It would also enable us to permit the water to pass more slowly through the basin and to remove a larger amount of sediment. It has been our aim at all times to make safety the first principle and we think we have fairly well accomplished that. The number of bacteria in the final effluent is reduced to a minimum of two or three per cubic centimeter. We feel sure that the quality of the water would be improved by enlarging the means of purification by the basin. We feel assured of this because of the great work that the sedimentation basin has done so far. The question of the quality as to taste and odor is a complicated one involving the knowledge of the action of the chlorin on the various impurities in the water. If we take out these impurities by sedimentation basins we will have less trouble from taste and odor. At least that has been our observation so far.

As compared with the raw water that was used forty-seven years ago, when the public were not critical in regard to their water supply, great progress has certainly been made, but people have become intensely critical in regard to the quality of water that they use. It is proper that they should be and every effort would be made to give not only a safe but a desirable water.

Our plant should be studied with reference to the needs and conditions for a new plant which we will have to install in a few years. The study of the reactions of the chemicals used with reference to the various changes in the water during the different seasons will give us, we hope, sufficient data to use more scientific methods in the purification of water in our new plant. Professor Mortenson deserves great credit for the work he has done in studying and reporting in his valuable paper on "The Use of Hydrogen Measurements in Connection with the Purification of Water at Cedar Rapids."

MUNICIPAL WATER SOFTENING IN ILLINOIS[1]

By A. M. Buswell[2]

An examination of the table (Water Survey Bull., 16, p. 77) shows that the majority (186) of the waters in Illinois have a hardness of from 300 to 600 parts per million. Only 1 water, from Mount Olive, has a hardness of less than 100, only 7 less than 200 and only 38 less than 300. Compared with the water supplies in the East these waters are extremely hard. For example, in Massachusetts only 16 well waters and one surface water used for municipal supplies have a residue of more than 200 parts per million. In Illinois, in addition to the waters already mentioned, 58 have a residue between 600 and 1000; 57 have a residue between 1000 and 2000; 11 between 2000 and 3000; 5 between 3000 and 4000; 1 between 4000 and 5000 and 1 has more than 5000.

Data were presented to show that either of two items would justify municipal water softning

1. The soap waste in a town of 40,000 inhabitants with a water of 300 p.p.m. hardness amounts to a ton per day.
2. The cost of operating pumps, cisterns and pressure pump for even 10 per cent of the population would probably pay for a municipal water softening plant.

The effect of hard water on the growth of a city is illustrated by two towns in the state where the water is exceedingly hard. These towns have had very little growth in the last twenty years, while other towns similarly situated but with better water supplies have grown rapidly.

The use of the very highly mineralized waters seems impracticable and an attempt should be made to obtain better waters if any are available.

[1] Abstract of paper before the Illinois Section meeting, March 22, 1923.

[2] The Chief, State Water Survey Division, Urbana, Ill.

DISCUSSION

Mr. T. N. Veatch, Jr.:[3] Mr. Buswell's paper was one of the most instructive that it has been my pleasure to hear on the subject of municipal water softening.

The question of municipal water softening is constantly becoming of greater importance and is receiving more and more study on the part of water works officials and engineers as well as by the public generally. Water softening on a large scale by municipalities is not an experiment by any means, as the successful operation of such projects has been proved in quite a number of cases.

We have been connected with several municipal water softening plants in this section of the country, among them being the plants at Lawrence, Topeka and Manhattan, Kansas. In each case the public, from all appearances, is very much pleased with the results and does not regret the money spent in the improvements.

Dr. Buswell's paper outlines clearly the benefits to be derived from a soft water supply and it is my belief that water softening will be undertaken extensively, especially in regions where hard water is the rule rather than the exception.

A word of caution in connection with the subject of municipal water softening might not be amiss. In carrying on the campaign, which is almost always necessary to obtain funds for municipal softening plants, it is easy to make too elaborate claims in regard to the results that may be expected. There is a big question whether it is ever practical to try and produce a water with less than 130 p.p.m. of total hardness and certainly not less than 100 p.p.m. unless the town is largely made up of industries requiring soft water. There are cases, of course, where further softening might be justifiable and there are undoubtedly cases where the public might be educated to the point where they would gladly pay the cost of softening even to a greater extent, but, speaking generally, the public can be entirely satisfied with a water, say at least as soft as the Lake Michigan water, which I understand is about 130 p.p.m.

The plant at Lawrence, Kansas has been furnishing water ranging in hardness from 100 to 150 p.p.m. and the people have been very much pleased. For a time the supply was obtained from wells having a hardness of about 400 p.p.m. Later on the source of supply

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was furnished from the Kansas River where the hardness varies from 200 to 400 p.p.m. depending on the stage of the river.

I have in mind the reaction that comes from "over selling" and I recall the elaborate claims that were once made by the advocates of the Cameron Septic Tank where the public was given to understand that, if the tank was installed, their troubles were ended forever. It has taken considerable education on the part of state departments and engineers to make the public realize that a sewage disposal plant really requires some attention. If care is used in presenting the question of municipal water softening, a general reaction may be avoided.

EFFECT OF THE NEW IMPOUNDING RESERVOIR ON FILTER PLANT OPERATION AT DECATUR[1]

By Wm. E. Stanley[2] and E. E. Ruthrauff[3]

GENERAL

Decatur obtains a water supply from the Sangamon River through a pumping station and a filtration plant located on the north bank of the river near the Illinois Central Railroad in the southern part of the city. A pumping station was constructed on the site of the present station in 1871. The present pumping equipment was largely installed in 1911. The present filter plant was put into operation in September, 1914, and has not been extended.

At first the water supply was taken from an infiltration gallery near the river. About 1878 a small wooden impounding dam was constructed across the river, which dam was later replaced by a concrete structure and raised to elevation 595 forming a reservoir of approximately 30 million gallons capacity.

In 1920 the construction of the present impounding dam was started and completed during the summer of 1922. The impounding dam consists of a concrete spillway section approximately 500 feet long, having a crest elevation of 610 with provision for raising the effective crest by means of flash boards to elevation 612. At each end of the concrete section are earthen dykes with tops at elevation 623.

With the water level at 610 at the dam, the reservoir formed will extend approximately 13 miles upsteam and has an estimated storage capacity of approximately 6 billion gallons, which is estimated to be sufficient to provide a minimum yield at the rate of $25\frac{1}{2}$ million gallons per twenty-four hours. This reservoir has been named Lake Decatur and is rapidly becoming of considerable scenic interest to people in and outside of Decatur.

[1] Presented before the Illinois Section meeting, March 20, 1924.

[2] Engineer, Pearse, Greeley & Hansen, Chicago, Ill.

[3] Chief Operator, Decatur Filtration Plant, Decatur, Ill.

A general plan showing the relative location of the reservoir and the city is shown in figure 1.

The impounding reservoir was completely filled first during March, 1922, before the dam was finished. It was necessary to empty the reservoir in order to close the dam and the reservoir was not again completely filled until early in March, 1923.

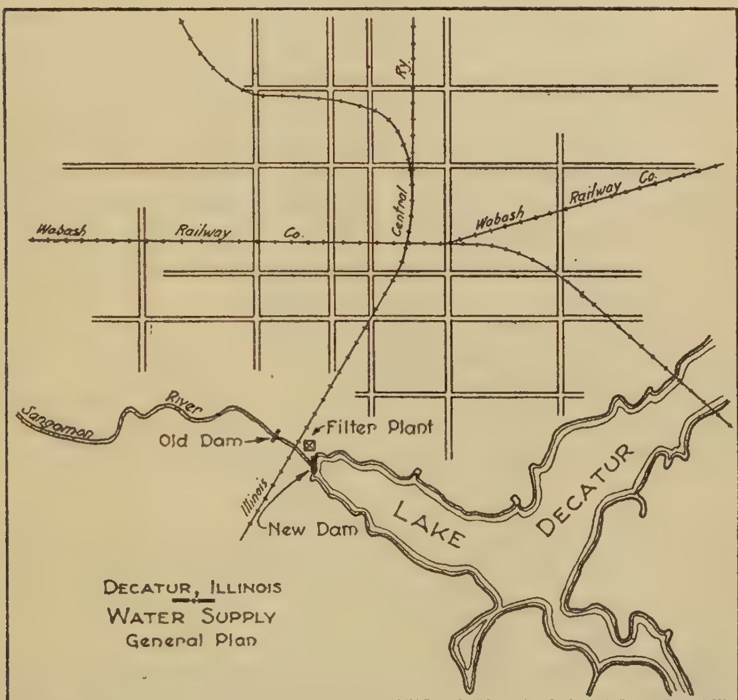


FIG. 1

Prior to the construction of the new impounding dam the storage reservoir was relatively small and probably had little effect upon the physical condition of the river water, except perhaps during periods of low flows in the summer seasons.

It is conceivable that the larger volume of water back of the new dam would have some appreciable effect upon the physical conditions of the river water and, consequently, upon the operation of the filter plant. The long, comparatively narrow body of water would tend to slow up the smaller flood flows and thus allow considerable of the

turbidity in the water to settle out before the water reaches the filter plant, and so decrease the load on the filter plant. On the other hand, large areas of the reservoir consist of shallow water which might tend to increase the load on the filter plant, especially during the summer seasons due to the growth of various microscopic organisms in the shallow and more or less stagnant waters.

The length of time which has elapsed since the new dam has been completed and the reservoir filled probably is too short to provide conclusive evidence as to the effect of the reservoir on the operation of the filter plant. However, it is hoped that the following operating data herein presented may be of some value as progress data indicating the effect of the reservoir, which may be amplified after a few years of operation from the reservoir. In line with presenting existing data as completely as possible, the available data covering the operation of the filter plant prior to the formation of Lake Decatur are given in as much detail as time and available records would permit.

FILTRATION PLANT

The water filtration plant is a gravity type, rapid mechanical filtration plant, with a nominal capacity of 9 million gallons per day. The process involves four main features, as follows:

Coagulation with alum
Sedimentation
Filtration
Sterilization with chlorine

The filter plant consists of a head house; a mixing basin; a coagulating basin of about $1\frac{2}{5}$ million gallons capacity; six filter tanks, each of $1\frac{1}{2}$ million gallons per day rated capacity, housed in a substantial filter house; and a filtered water reservoir with a total capacity of about 3 million gallons.

The filter building and head house form a single structure and are of concrete and brick construction with a slate roof. The remainder of the structures are of reinforced concrete.

The raw water is pumped to the filter plant by a set of two low lift pumps. As the water reaches the filter plant, it enters an influent well 9 feet by 20 feet 6 inches by 18 feet 6 inches deep, located beneath the headhouse. The coagulant is introduced into the water in this influent well. The water then flows through the mixing basin into the coagulating basins, thence to the filters.

The mixing basin consists of two parallel compartments each 83 feet long, 10 feet wide, and 18 feet 6 inches deep. One compartment contains vertical baffles which thoroughly mix the water. The two compartments provide a retention period of about twenty-five minutes at the rated capacity of the filter plant.

The coagulating basin consists of two sections which may be used either singly or together in parallel. To date, these sections have always been used together.

Sulphate of alumina is used as a coagulant. The alum solution is prepared in two concrete tanks, each with a capacity of 6000 gallons. A 5 per cent solution is made by charging each tank with 2450 pounds of alum. The alum solution feed is controlled by calibrated orifice boxes.

The amount of alum solution used for various conditions of turbidity and temperature of the raw water is regulated by observing the formation of the floc in the mxing basin. This method probably gives fairly accurate results for this particular plant, as all the plant operators have been with the plant since it was first put into operation, and have been careful with their observations. Rather complete records have been kept of the amount of alum used for various conditions of raw water and the results obtained.

OPERATING RECORDS

A complete daily record since starting the operating of the filter plant in September, 1914, has been kept by the filter plant operators of the following items:

- Pumpage
- Amount of wash water
- Alum
- Chlorine
- Turbidity of raw water
- Number of filters washed
- Length of wash
- Stage of river

A record of the following items has been kept for the period of time indicated:

Bacterial Analysis: Both raw water and filtered water daily since March, 1922, with occasional determinations prior to March, 1922.

Alkalinity: Daily records from March, 1922, to April, 1923, inclusive. Occasional observations for the remainder of the time.

Temperature of raw water: Daily records of temperature were kept for four years, 1916 to 1919 inclusive.

In addition to the records kept by the operators at the filter plant, analyses of the raw water and the filtered water have been made once a month by the State Water Survey Division, since 1916, and by the State Department of Public Health since 1920. These analyses give data on turbidity, color, odor, alkalinity, bacterial count, and the general sanitary condition of the water supply.

FILTER PLANT CAPACITY AND LOADINGS

The nominal capacity of the filter is 9 million gallons per twenty-four hours. The filtered water reservoir provides a storage capacity of approximately 3 million gallons. The monthly averages of daily water consumption steadily increased from an average of 3.5 m.g.d. in 1915 to a maximum monthly average of 8.1 m.g.d. in June, 1920 at which time the A. E. Staley Manufacturing Company put their own water supply into operation and the average monthly con-

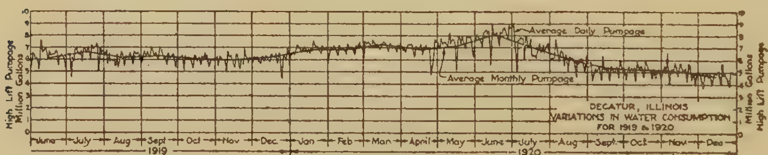


FIG. 2

sumption of city water dropped to 4 m.g.d. in April, 1921. Since April, 1921, the water demand has been steadily increasing to a maximum monthly average of about 6 m.g.d. during January, 1924.

During the period of maximum water demand in 1920, while the A. E. Staley Company were using such large quantities of city water, it was necessary to operate the filter plant at as much as fifty percent over capacity a great deal of the time. The average daily and average monthly pumpage rates for 1919 and 1920 are shown in figure 2.

CHARACTER OF THE RIVER WATER

The raw water supply is pumped directly from the river impounding reservoir to the filter plant. The Sangamon River is the largest tributary of the Illinois River and has a total drainage area above Decatur of about 862 square miles.

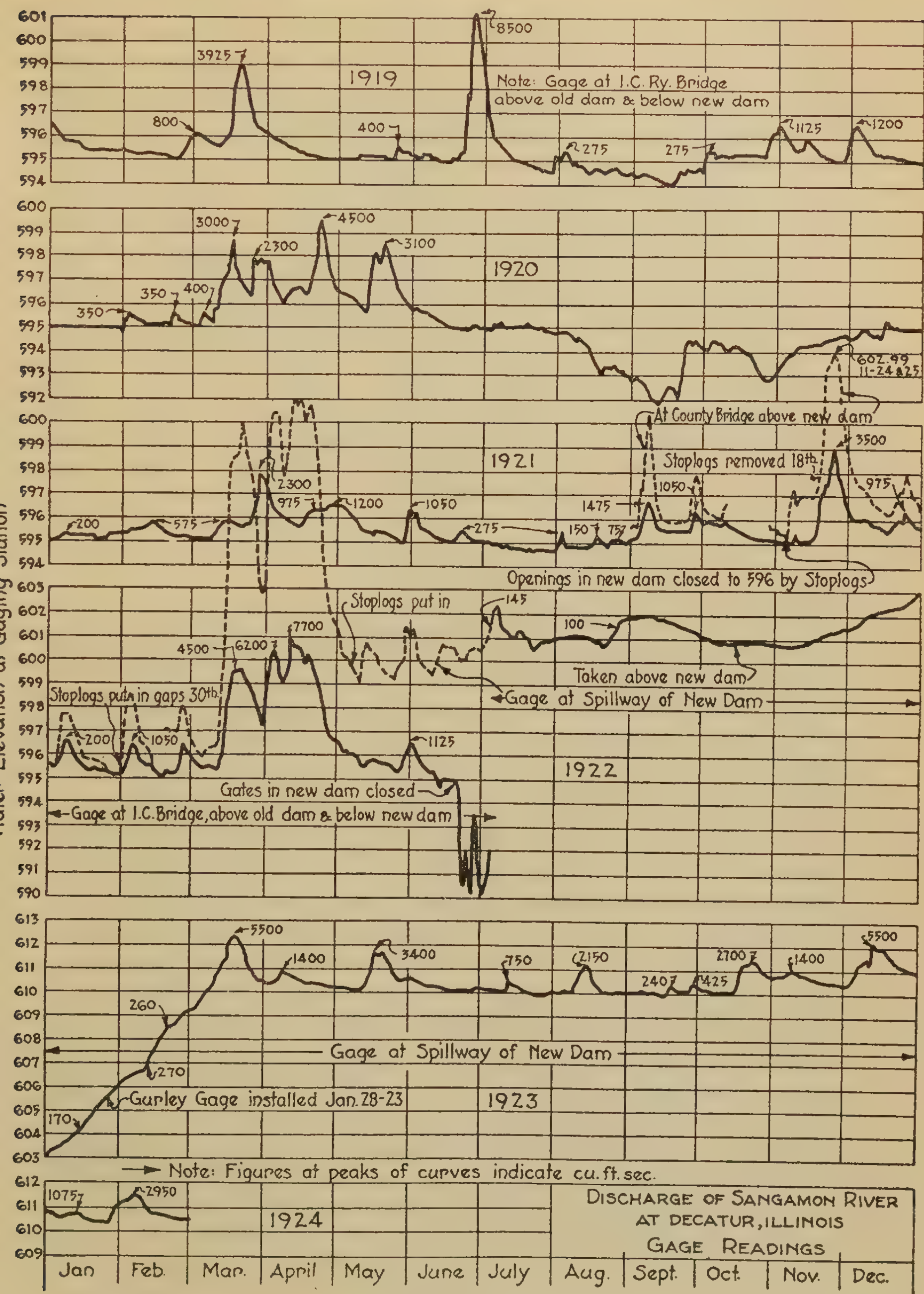

1919
Note: Gage at I.C. Ry. Bridge above old dam & below new dam
1920
At County Bridge above new dam
1921
Stoplogs removed 18th
Openings in new dam closed to 596 by Stoplogs
Stoplogs put in
Taken above new dam
Gage at Spillway of New Dam
Stoplogs put in gaps 30th
1922
Gates in new dam closed
Gage at I.C. Bridge, above old dam & below new dam
Gage at Spillway of New Dam
Gurley Gage installed Jan. 28-23
1923
Note: Figures at peaks of curves indicate cu. ft. sec.
1924
DISCHARGE OF SANGAMON RIVER
AT DECATUR, ILLINOIS
GAGE READINGS
Jan
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

FIG. 3

In a general way, the Sangamon River has the characteristic flashiness of middle western streams. The stream flow at Decatur has varied from a minimum of approximately 7 cubic feet per second to an average yearly flood flow of about 7000 cubic feet per second (see fig. 3) with a maximum flood in 1913 of something over 18,000 cubic feet per second.

The physical characteristics of the river water as observed at Decatur in its relation to the operation of the filter plant and the effect of the new impounding reservoir on the operation of the filter plant may be classified under the following headings:

Turbidity
Color
Alkalinity and hardness
Bacterial content
Tastes and odors

Turbidity

Daily observations and records of the turbidity of the river water have been made since November, 1914. The turbidities of the river water have been quite variable as would be expected (see fig. 4). The turbidities have ranged from around 15 parts per million during periods of low river flow to as high as 5000 parts per million during some high flood flows.

Records are available showing the results of a total of 2256 observations of the turbidity of the river water covering a period of six years prior to the formation of the new impounding reservoir (Lake Decatur) and the results of 639 observations of the turbidity of the water from the new reservoir covering a period of twenty-one months since the formation of the reservoir. These results indicate a very material reduction in the turbidity of the raw water. (see table 1). These data show that, before the formation of the reservoir, for about 25 per cent of the time the turbidities were 100 parts per million or greater and for 5 per cent of the time the turbidities were 500 parts per million or greater, while, since the formation of the reservoir, the turbidities for 25 per cent of the time have been 50 parts per million or greater and for 5 per cent of the time 150 parts per million or greater.

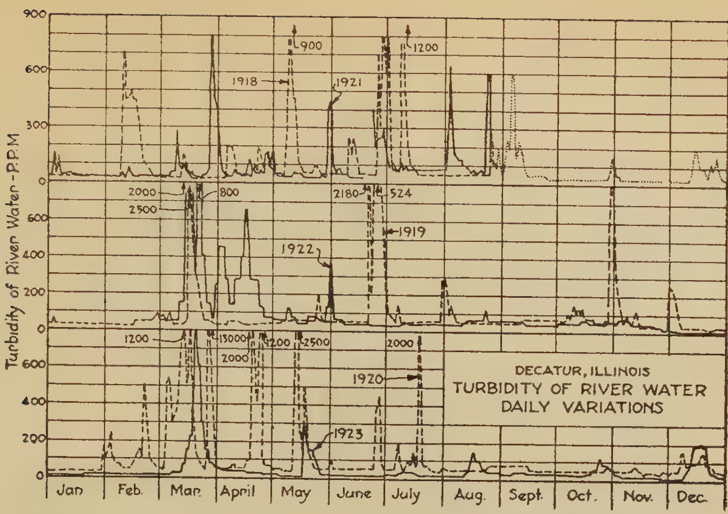
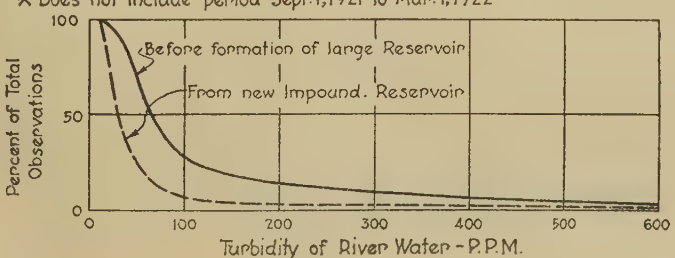


FIG. 4

Table 1
Filter Plant Operation at Decatur, Illinois
Turbidity of River Water
Period 1915 to 1924

P.P.M. Turbidity	Observations of Turbidity equal to or greater than amount given in 1st Column — Sept. 1915 to April 1922 inc.* No. Observations	Percent of Total	May 1922 to Feb. 1924 inc. No. Observations	Percent of Total
10	2256	100	639	100
30	2096	93	354	55
50	1607	71	163	25
100	642	28	49	7.8
150	418	19	31	4.9
200	321	14	15	2.3
300	200	8.9	7	1.1
400	151	6.7	4	0.6
500	99	4.4	4	0.6
600	75	3.3	4	0.6
800	41	1.8	2	0.3
1000	29	1.3	0	0
1500	22	1.0	0	0
2000	17	0.8	0	0
5000	2	0.1	0	0
Total No. Observations	2256	100	639	100
Length of Period	72 months *		21 months	

* Does not include period Sept. 1, 1921 to Mar. 1, 1922

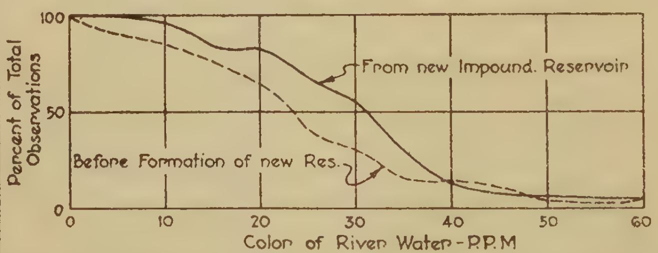


Color

Observations of the color of the raw water have been made approximately once a month since 1916 by the State Water Survey Division and approximately once a month since 1920 by the State Department of Public Health. These observations show a range from no color to a color of 80 parts per million, before the formation of the

Table 2
Filter Plant Operation at Decatur, Illinois
Color of River Water
Period 1916 to 1924

P.P.M. Color	Observation of Color equal to or greater than amount given in 1st Column: Aug. 1916 to Mar. 1922 inc. No. Observations	Aug. 1916 to Mar. 1922 inc. Percent of Total	April 1922 to Jan. 1924 inc. No. Observations	April 1922 to Jan. 1924 inc. Percent of Total
0	64	100	34	100
5	58	90	34	100
10	55	86	33	97
15	49	77	29	85
20	42	66	28	82
25	25	39	23	68
30	19	30	19	56
35	10	16	10	29
40	9	14	4	12
50	3	4.7	2	5.9
60	2	3.1	1	2.9
80	1	1.6	0	0
Total No. Observed	64	100	34	100



impounding reservoir and a range of from 5 to 60 parts per million since the formation of the reservoir. The observations of color before and after the formation of the impounding reservoir indicate an increase in color ranging from 10 to 30 per cent (see table 2). It is likely that this increase in color is largely due to decaying vegetation as the reservoir site was not stripped before filling, and that the amount of color will decrease somewhat with time.

Alkalinity and Hardness

Determinations of the alkalinity of the raw water were made at the filter plant daily from March, 1922, to April, 1923, and occasionally during the remainder of the period of the operation of the filter plant. Additional observations have also been made approximately once a month by both the State Water Survey Division and the State Department of Public Health.

The alkalinity ordinarily runs about 250 parts per million. However, there are considerable variations in alkalinity with variations

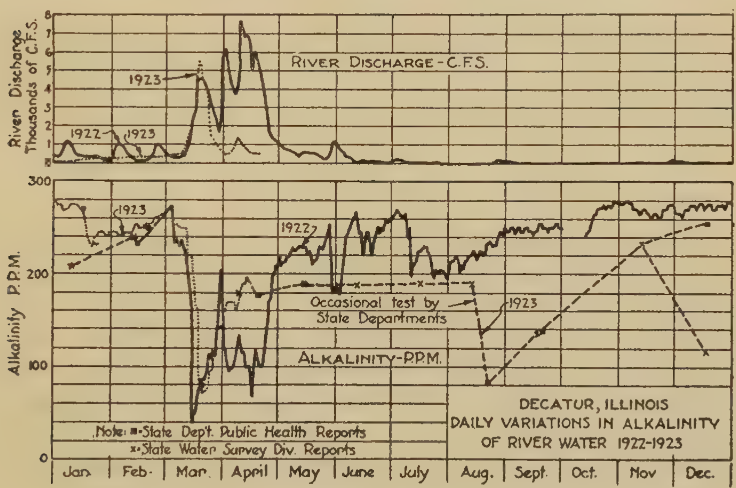


FIG. 5

in the flow of the river (see fig. 5) and a few times during large floods, the alkalinity has dropped as low as 40 parts per million, so low that there was an insufficient amount to coagulate the water properly without addition of lime. The observations of alkalinity have been too few to indicate any very definite effect of the reservoir on the alkalinity. It is likely that the reservoir will tend to stabilize the alkalinity and prevent it dropping so low as to necessitate the use of lime at the filter plant.

Only a few determinations of the hardness of the raw water have been made. The recorded results of hardness determinations are as follows:

DATE	HARDNESS ($Ca\ CO_3$)	REMARKS
	p.p.m.	
December, 1920	136	Determined by soap method
January, 1921	151	Determined by soap method
February, 1921	128	Determined by soap method
March, 1921	126	Determined by soap method
April, 1921	126	Determined by soap method
May, 1921	124	Determined by soap method
January, 1924	189	Determined by soda reagent method
February, 1924	166	Determined by soda reagent method

These results indicate a hardness of about 130 parts per million of $CaCO_3$ before the formation of the reservoir as determined by the soap method and a hardness of about 170 parts per million of $CaCO_3$ of the water from the reservoir as determined by the soda reagent method.

Bacterial content

Daily bacterial analyses have been made at the filter plant since March, 1922, of the raw water and also the filtered water. Analyses have also been made about once per month by both the State Water Survey Division and the State Department of Public Health. These analyses show wide variations in the number of bacteria in the raw water (see fig. 6). There is not much indication that the impounding reservoir has had much influence on the number of bacteria in the river water, except, perhaps, the first few months while the reservoir was filling. However, the number of the observations are too few to give decisive indications.

Tastes and odors

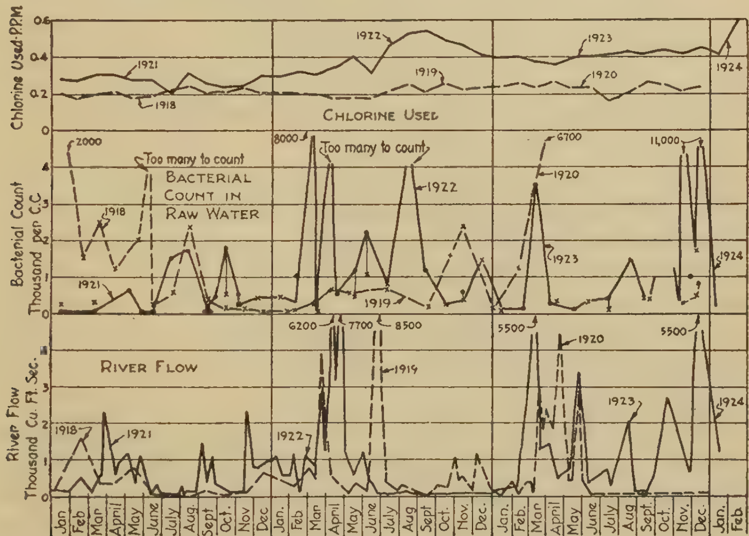
Unfortunately little record has been kept of the growth of microscopic organisms in the river water before and after the formation of the new reservoir. Observations of odors have been made about once a month, as a routine part of the analysis by the State Water Survey Division and also by the State Department of Public Health.

Considerable trouble with bad tastes and odors in the filtered water was experienced the later part of January and the first part of February, 1923. These tastes and odors were attributed to Synura in the impounding reservoir. The disagreeable tastes and odors were reduced to some extent by using an excess of alum and chlorine

in the filtration of the water. A total of approximately 16,000 pounds excess alum was used during a period of one month or an average of about 104 pounds per million gallons of water filtered.

Chemical treatment

The chemicals used at Decatur are sulphate of alumina or alum used as a coagulant in the clarification of the raw water and chlorine used for sterilization of the filtered water, as it goes from the filter plant to the high lift pumps.



DECATUR, ILLINOIS
RELATION OF RIVER FLOW - BACTERIAL COUNT - CHLORINE USED

FIG. 6

The experience at Decatur indicates that the amount of alum required to clarify properly the raw water depends largely upon the turbidity and the temperature of the raw water, although other factors such as the color and the microscopic organisms have been observed to affect materially the amount of alum required at times, usually during periods of heavy rain fall in the fall of the year.

Daily records of the turbidity and temperature of the raw water, and the amount of alum used were kept for the four years, 1916 to 1919, inclusive. These data have been classified so that the observa-

tions are divided into classes as to turbidity and temperature of the raw water. The results of these classifications are given in figure 7. These data indicate an increase in the amount of alum required when the temperature of the raw water is from 0 to 5°C. over the amount of alum required when the temperature of the water is from 25 to 30°C. of about 25 per cent for average turbidities of 50 parts per million and 100 per cent when the turbidities are 200 to 400 parts per million.

Daily records have been kept of the turbidity of the raw water and the amount of alum used for the entire period of operation of the filtration plant. Monthly averages have been worked up from the daily records and plotted in figure 8. These monthly average figures show a decided decrease in the turbidity of the raw water after the formation of the new impounding reservoir and a corresponding reduction in the amount of alum used.

A continuous record has also been kept of the amount of chlorine used for sterilization of the filtered water. The amount of chlorine used has been controlled by the count of bacteria in the water after chlorination, sufficient chlorine being used to keep the number of bacteria always below 100 per cubic centimeter and usually well below 50 per cubic centimeter. Recently the control of the chlorination has been by determinations of the residual chlorine by the ortho-tolidine method.

The monthly average amounts of chlorine used in parts per million are shown in figure 8. These figures show a material increase in the amount of chlorine used after the formation of the new impounding reservoir. Part of this increase in the chlorine requirements may probably be accounted for by the increase in the number of bacteria in the raw water (see figure 6). The larger part of the increase in the chlorine requirements, however, is probably due to decreased efficiency of the filter beds.

The filter beds were originally constructed with 9 or 10 inches of graded gravel and 30 inches of silica sand from Ottawa, Illinois. The sand had an effective size of 0.32 m.m. and a uniformity coefficient of 1.81 when put in the filters in 1914. Since the plant has been in operation, the thickness of the sand beds has been reduced to about 24 inches by losses in washing and cleaning the beds and the size of the sand grains has been enlarged by a coating of iron and manganese. An analysis of the coating in 1921 by the State Department of Public Health showed that it contained 0.9 per cent of

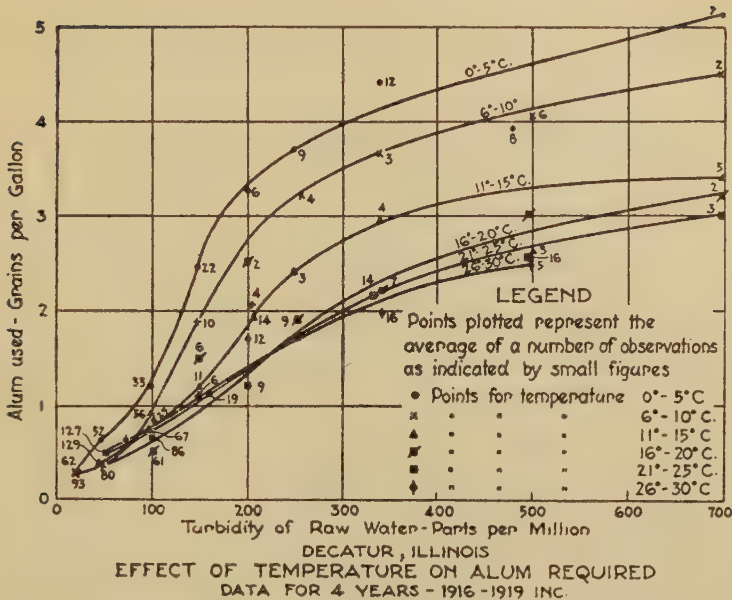

Alum used - Grains per Gallon
Turbidity of Raw Water - Parts per Million
0°-5°C.
6°-10°
11°-15°C.
16°-20°C.
21°-25°C.
26°-30°C.
LEGEND
Points plotted represent the average of a number of observations as indicated by small figures
• Points for temperature 0°- 5°C
6°- 10°C.
11°- 15°C
16°- 20°C.
21°- 25°C.
26°- 30°C
DECATUR, ILLINOIS
EFFECT OF TEMPERATURE ON ALUM REQUIRED
DATA FOR 4 YEARS - 1916 - 1919 INC.

Fig. 7

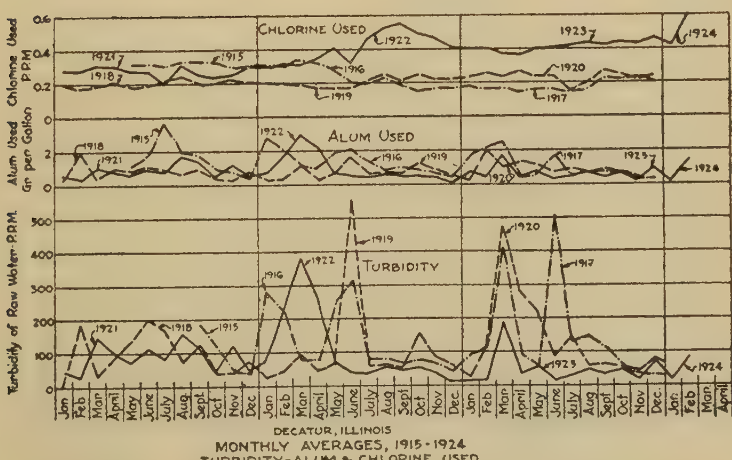

Chlorine Used P.P.M.
Alum Used Gr. per Gallon
Turbidity of Raw Water - P.P.M.
Chlorine Used
Alum Used
Turbidity
DECATUR, ILLINOIS
MONTHLY AVERAGES, 1915 - 1924
TURBIDITY - ALUM & CHLORINE USED

Fig. 8

TABLE 3

Filter plant operation at Decatur, Illinois

Cost of chemicals

YEAR ENDING APRIL 30	AVERAGE HIGH LIFT PUMPAGE	ALUM				CHLORINE				COST*	
		Total	Average grams per gallon	Cost*		Total	Average†	Cost*		Alum and chlorine	
				Total	Per million gallons			Total	Per million gallons	Total	Per million gallons
	m.g.d.	*pounds*				*pounds*	*p.p.m.*				
1916	4.08	367,705	1.74	$3,475.79	$2.33	11,540	0.32	$224.06	$0.16	$3,700.85	$2.49
1917	4.91	359,200	1.37	4,419.07	2.46	8,691	0.19	472.20	0.26	4,891.27	2.72
1918	5.25	208,215	0.72	3,669.35	1.85	9,318	0.19	351.58	0.18	4,013.93	2.03
1919	5.63	203,668	0.69	3,757.01	1.83	10,435	0.20	379.80	0.18	4,136.19	2.01
1920	6.47	416,483	1.20	7,540.63	3.19	13,913	0.23	525.63	0.22	8,066.26	3.41
1921	5.63	224,374	0.76	4,242.29	2.07	2,802 3,162 ‡	0.20	626.90	0.31	4,869.19	2.38
1922	4.85	334,316	1.29	6,228.12	3.52	4.204	0.27	578.40	0.32	6,806.52	3.84
1923	5.27	169,794	0.57	2,657.88	1.38	6,998	0.42	768.75	0.40	3,426.63	1.78
1924§	5.74	150,910	0.69	2,147.63	1.41	7,476	0.57	901.54	0.58	3,049.17	1.99

* Includes cost of chemicals delivered in filter plant.

Hypo-chlorite of lime used until July, 1920, liquid chlorine thereafter.

† Free chlorine based upon $33\frac{1}{3}$ per cent free chlorine in hypo-chloride used.

‡ 802 pounds of hypo-chloride and 3162 pounds of liquid chlorine were used.

§ Ten months to March 1, 1924.

iron, 0.1 per cent of manganese, and the remainder organic material. Sieve analyses of the filter sand since 1920 indicate a progressive increase in the size of the sand grains, as follows:

DATE	EFFECTIVE SIZE	UNIFORMITY COEFFICIENT
1914	0.32	1.81
February, 1921	0.44	1.14
February, 1923	0.56	1.13
March, 1924	0.57	1.13

Arrangements are now being made at Decatur to replace the filter sand.

TABLE 4

Filter plant operation at Decatur, Illinois

Total annual operating cost of filter plant

YEAR ENDING APRIL 30	AVERAGE HIGH LIFT PUMPAGE	COST OF CHEMICAL	WASH WATER		ATTENDANTS AND MISCELLANEOUS LABOR‡	SUPPLIES AND REPLACEMENTS	STEAM HEAT	TOTAL COST OF OPERATION	
			Million gallon used	Cost†				Total	Per million gallons
	m.g.d.								
1915*	3.58	$1,944.48	10.42	51.21	$2,930.00	$5.00	$722.64	$5,653.33	$6.46
1916	4.08	3,700.85	21.45	107.25	4,370.00	10.00	1,084.05	9,272.15	6.22
1917	4.91	4,891.27	27.23	136.15	4,570.00	135.00	1,084.05	10,816.47	6.03
1918	5.25	4,013.93	25.57	127.85	5,570.00	10.00	1,084.05	10,805.83	5.63
1919	5.63	4,136.19	25.83	129.15	4,670.00	12.00	1,084.05	10,031.39	4.89
1920	6.47	8,066.26	35.72	178.60	4,370.00	15.00	1,084.05	13,713.91	5.80
1921	5.63	4,869.19	32.12	160.60	4,550.00	880.00‖	1,084.05	11,543.84	5.63
1922	4.85	6,806.52	33.10	165.50	4,550.00	15.00	1,084.05	12,621.07	7.13
1923	5.27	3,426.63	39.30	196.50	4,730.00	1,410.00•	1,084.05	10,847.18	5.63
1924§	5.74	3,049.17	34.53	172.75	4,540.00	8.00	903.30	8,673.22	4.97

* Eight months September, 1914, to April 30, 1915.

† Based on estimated cost of low pumpage and steam for wash water pump.

‡ Miscellaneous labor for cleaning basins and work about plant estimated at $50 per year.

§ Ten months ending February 29, 1924.

‖ Wallace and Tiernan chlorinator replacing hypo tanks.

• First chlorinator repaired ($300) new vacuum type machine added.

OPERATING COSTS

A record has been kept since 1915 of the amount of alum and chlorine used and the cost of each delivered at the filter plant. These data, given in table 3, show that the total cost of chemicals has materially decreased since the formation of the new reservoir.

The total annual costs of operating the filter plant are given in table 4.

The total operating costs have ranged from $7.13 for the year ending April 30, 1922 to $4.97 per million gallons for the ten months ending Feb. 29, 1924. The reduction in the cost of chemicals has been $3,800 or $1.85 per million gallons of water filtered.

SUMMARY AND CONCLUSIONS

The data available to date covering the operation of the filter plant at Decatur before and after the formation of the new impounding reservoir indicate that the reservoir is a material benefit in reducing the load on the filter plant.

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

The American Water Works Association opened its forty-fourth annual convention at the Hotel Astor, New York City, during the week of May 19, 1924.

Monday, May 19, was spent in registration of members, meetings of executive committees and special committees, and round table discussions on superintendent's topics, coöperation between water works and fire protection men, standard methods of water analysis, loadings for purification processes, colloid chemistry, data for water records and purification of boiler waters.

On Monday evening a testimonial dinner was held for members and guests in honor of J. M. Diven, who retired as Secretary after twenty-two years of service. The dinner was marked by great enthusiasm in demonstrating the respect and love for an official whose untiring activities for the Association during such a long period were the source of much comment. At a later meeting of the Executive Committee Mr. Diven was made Secretary Emeritus and an honorary member of the Association.

The opening session of the convention was called to order by President Fuller at 9:30 a.m. on Tuesday, May 20. With no opposition ticket the chair instructed Acting Secretary Diven to read the list of officers elected for the ensuing year: President, Frank C. Jordan; Vice-President, Harry F. Huy; Treasurer, William W. Brush; Director, J. Arthur Jensen.

Secretary Diven then read the report of the executive committee, including a summary of the report of the secretary and the treasurer.

Chairman Fuller announced that contracts had been let for the publication of the "Manual of Americal Water Works Practice" and that the Association was about to coöperate with the Public Health Association for the publication of "Standard Methods of Water Analysis."

Three honorary members were unanimously elected, as follows: H. E. Keeler, John M. Diven and Clemens Herschel.

Several important changes in the constitution of the association were brought before the convention. These were read by the secretary, article by article, and each one was voted upon separately. All were carried. These changes appear in the September Supplement to the JOURNAL.

Nicholas S. Hill, Jr., reported for the Committee on Private Fire Protection Services that it had been inoperative for some two years.

Edward E. Minor, of the representatives on the American Committee on Electrolysis, reported that a great good had been accomplished by the American Committee by bringing together those who suffered from the trouble of electrolysis and those who caused these troubles.

Mr. Fuller said that the association would work with the Committee on Electrolysis provided that no funds were taken from the treasury. The report of the committee was approved and it was continued. Seth M. Van Loan reported progress for the committee on Standard Specifications for Water Meters.

The Committee on Standard Form of Contract was reported for by John M. Goodell, its secretary. He said that the last convention of the Association approved for trial a contract provided by the Association and other organizations. The committee submitted a number of recommendations and other associations made further suggestions. During the year Messrs. Waldo Smith, Chester and Davis attended conferences. The committee has revised slightly the form of contract, with all recommendations of the Association accepted. The printing of the document has not yet been completed. The committee was continued.

President Fuller reported for the Standardization Council. He emphasized the necessity for the proper discussion by the members of the convention, of the various committee reports, so that the council may know the views of the members on the subject.

The first paper of the session was by L. P. Wood on Allocation of Water Supply Derived from Water Sheds of Interstate Streams.[1] Discussion by J. W. Smith and M. Knowles.

It was followed by Iodine Treatment of the Rochester Water Supply,[2] by Beckman C. Little; discussion by M. Tolman, J. J. Hinman, Jr., J. W. Ellms, S. G. Highland and G. C. Whipple.

[1] Journal, May, 1924, page 521.

[2] This Journal, page 68.

On the opening of the afternoon session the members decided to petition for the formation of a Fire Protection Division. This Division was later approved by the Executive Committee.

The following papers were presented: The Method of Making Flow Tests and Their Value to the Water Works Engineer, by George W. Booth. The Relation of Fire Protection Requirements to the Distribution System of Small Towns, by C. Goldsmith. The Economic Significance of the Fire Waste, by F. H. Wentworth.

Mr. Jordan at this point called for nominations for officers of the Fire Prevention Division.

Frank A. Barbour nominated the following, who were unanimously elected. Chairman, Nicholas S. Hill, Jr.; Vice-chairman, Allan W. Cuddeback; Secretary-treasurer, Clarence Goldsmith.

Mr. Jordan retained the chairmanship of the meeting. He called upon V. Bernard Siems, who read his paper on Fire Flow to be Provided in Large Cities under Various Conditions of Risk.[3] This paper was followed by a paper by Louis Stocklmeir on Effect of Distribution System Design upon the Fire Insurance Rates.[4]

This group of papers was discussed by J. H. Howland, George W. Booth, William Luscombe, Abel Wolman and several others.

At five o'clock the chair called for nomination by districts for members of the nominating committee. Several of the districts were not ready to report their candidates.

Those who had decided on candidates were District No. 2, New England States, Stephen H. Taylor, New Bedford, Mass.; No. 3, New York, Frederick E. Beck, Utica, N.Y.; No. 5, V. Bernard Siems, Baltimore, Md. The meeting then adjourned.

The evening session was under the auspices of the Water Works Manufacturers' Association. John F. Reagan, president of the Manufacturers' Association, presided. The first paper by Alan Johnstone was on What Water Really Is. The second paper was by W. L. Egy, on The Development and Manufacture of Engineering and Surveying Instruments. These were followed by Progress in the Chemistry of Precipitation and Coagulation, by H. M. Spencer; The Development and Manufacture of the Modern Cement-Lined Service Pipe, by R. J. Newsom; Observations On the Chlorination of Small Water Supplies, by M. J. Tiernan.

[3] Journal, January, 1924, page 17.
[4] Journal, May, 1924, page 572.

A card party was given to the ladies of the convention, under the auspices of the Water Works Manufacturers' Association, in charge of the Ladies' Entertainment Committee.

Morning session, May 21. Presiding officer, President Fuller.

The nominations for the nominating committee as completed by the various districts were as follows: No. 1—O. D. Brown, Walkerville, Ont.; No. 2—Stephen H. Taylor, New Bedford, Mass.; No. 3—Fred Beck, Utica, N. Y.; No. 4—G. C. Gensheimer, Erie, Pa.; No. 5—V. Bernard Siems, Baltimore; No. 6—John W. Toyne, South Bend, Ind.; No. 7—L. B. Mangun, Kansas City, Kan.; No. 8—H. E. Keeler, Chicago; No. 9—W. W. Hurlburt, Los Angeles, Cal.

All were unanimously elected.

The new trustees are: District No. 1, Alexander Milne, St. Catharines, Ontario; No. 4, Edgar M. Hoopes, Jr., Wilmington, Del.; No. 5, J. E. Gibson, Charleston, S. C.; No. 8, J. A. Jensen, Minneapolis, Minn., and District No. 9, F. M. Randlett, Portland, Ore.

The first report was by Chairman S. T. Powell, of Standardization Committee No. 11 on Sanitary Fountains.[5] The report was accepted and the committee discharged.

At this point the chair introduced C. N Avery, Chairman of the Texas Water Works Association, who addressed the convention. Mr. Avery hoped the Texas Association would soon become a division of American Water Works Association. He expressed his appreciation of the courtesies extended to him by the members.

The next committee to report was No. 2 of the Standardization Council on Standards for Satisfactory Drinking Water. The report was presented by Abel Wolman for Dr. Allen W. Freeman. Dr. A. J. McLaughlin spoke on the administrative control of water supplies by the United States Public Health Service.

George C. Whipple, read a paper on Government Requirements and Professional Standards.[6]

The report and paper were freely discussed by H. E. Jordan, F. E. Hale, Jack J. Hinman, Jr., J. W. Ellms, Edward Bartow, William Gore, Norman J. Howard, Abel Wolman and several others.

At 12 o'clock, as a special order of business, the selection of the next place of meeting was taken up. The chair appointed as tellers Dennis O'Brien, W. S. Cramer and John N. Chester. Acting

[5] Journal, March, 1924, page 483.

[6] This Journal, page 61.

Secretary Diven read the list of cities recommended by the executive committee as eligible in the order of their choice.

The executive committee recommended a number of cities which had applied for the convention next year, but this was narrowed down to Louisville, Ky.; Atlanta, Ga.; Baltimore, Md.; and Milwaukee, Wis. Louisville was chosen as the convention city for 1925.

The session then adjourned.

Afternoon session, May 21. Presiding officer, President Fuller.

The first paper of this session was on Large Water Supply Mains[7] by Dabney H. Maury; discussion by G. W. Fuller, N. S. Hill, Jr., E. G. Ritchie, C. B. Burdick, W. Gore, W. W. Brush, L. P. Wood, J. E. Gibson, T. A. Leisen, G. J. Requardt and D. H. Maury.

T. A. Leisen described methods of cleaning the Omaha sedimentation and coagulation basins.

It was announced that W. S. Cramer had been elected as chairman and J. M. Diven as secretary of the Plant Operation and Management Division.

The session adjourned.

The ladies of the convention were entertained at 8 p.m. by a performance at the Hippodrome. At ten o'clock the men were given a smoker in the Roof Belvedere of the Hotel Astor. Both were given through the courtesy of the Water Works Manufacturers' Association.

Morning session, May 22. Presiding officer, President Fuller.

Thaddeus Merriman spoke on Arrangment for Preventing Pollution of the Catskill Water Supply.

This paper was followed by the report of Committee No. 5, on Watershed Protection,[8] W. L. Stevenson, chairman. This report was discussed by C. A. Holmquist, W. W. Brush, C. B. Mark, Ivan M. Glace, L. D. Matter, J. W. Fortenbaugh, C. L. Siebert, J. H. Bridgers, Robert S. Weston and others.

The next report discussed was on Industrial Wastes in Relation to Water Supply.[9] Almon L. Fales, as chairman of the committee, gave a brief summary of the report, which was discussed by H. E. Moses, E. S. Tisdale, J. W. Ellms and C. A. Emerson, Jr.

[7] This Journal, page 1.
[8] Journal, May, 1924, page 613.
[9] Journal, May, 1924, page 628.

At this point Mr. Fuller turned the convention over to the new president, F. C. Jordan.

The final committee to report for the session was No. 12, on Testing of Water Works Materials and Supplies,[10] T. H. Wiggin, chairman. The report was discussed by Thaddeus Merriman, A. D. Flinn, L. P. Wood, F. W. Green and John R. Baylis.

At 1 o'clock the entire convention embarked upon the "Onteora" and were taken for a sail on the Hudson River, landing at Bear Mountain at about 4:30. At 5:30 an excellent dinner was served in the Bear Mountain Inn, with an orchestra and song leader to enliven the occasion. The trip was under the auspices of the Water Works Manufacturers' Association and in direct charge of William C. Sherwood and Theodore R. Kendall.

Morning session, May 23. Presiding officier, G. W. Fuller.

Action of Water on Service Pipe[11] by Wellington Donaldson was the first paper presented as contribution to the work of Committee No. 10.

The report of Committee No. 10, Standardization of Services, by J. M. Diven, followed. This report was discussed by F. N. Speller, Robert S. Weston, David Heffernan, G. C. Whipple and W. Donaldson.

The report of Committee No. 7, Pumping Station Betterments, by Leonard A. Day, chairman, was followed by a paper on Operating Experiences and Economy of a Diesel Engine Driven Pumping Station, by P. deW. Vosbury; discussion by John N. Chester, L. A. Day, Kerr, P. Vosbury and R. D. Hall.

Afternoon session, May 23.

The final session of the convention was well attended and was marked by lively discussion on several important topics of interest to superintendents. James E. Gibson was in the chair.

Among the questions debated were the matter of distributing the purchase of pipe over the year so as to relieve the congestion in the pipe foundries.

George R. Taylor told of an experience with Synura and other water-borne organisms and his methods of using copper sulphate when his reservoir was covered with ice. This was discussed by F. C. Dugan and J. E. Gibson.

Use of the flushometer was discussed by J. M. Diven, D. H. Heffernan and S. L. Mosely.

[10] Journal, May, 1924, page 663.

[11] Journal, May, 1924, page 649.

The use of pipe jointing compounds was discussed by J. M. Diven, C. A. Spencer, R. C. Wilson and W. H. Buck.

Leak detecting instruments were discussed by L. E. Moore, F. Henshaw, D. H. Heffernan, H. B. Foote and J. E. Gibson.

The question of changing meters in testing them and the best method of keeping track of the meters was discussed by H. B. Foote, J. E. Gibson, J. G. Valentino, H. T. Gidley and F. Henshaw.

Fire protection services were discussed by Harry A. Burnham, J. M. Diven, H. B. Foote, W. H. Buck and J. E. Gibson.

Water shortage was discussed by J. E. Gibson, O. E. Bulkeley, J. M. Diven, J. G. Valentino and others.

The question of extensions brought up the installation of service connections in vacant property, which was discussed by J. G. Valentino D. H. Heffernan, J. N. Chester, T. R. Duggan and J. M. Diven.

Chemical and Bacteriological Division. At 2:00 p.m., May 20, the Chemical and Bacteriological Division met in the Laurel Room, with A. L. Fales, Chairman, presiding. The progress report of the Committee on Standard Methods of Water Analysis was made by its chairman, Jack J. Hinman, Jr., and was very freely discussed by R. C. Bardwell, A. M. Buswell, L. H. Enslow, C. R. Knowles, J. W. Ellms, L .I. Birdsall, H. G. Dunham, M. McCrady, H. E. Jordan and N. J. Howard. This was followed by several papers, as follows: "A Defect in Permanent Color Standards due to Variations in Cobalt Chloride," by M. C. Whipple; "Color Transmittancy Curve by Some of the Colorimetric Standards including Cobalt Chlorides," (illustrated with lantern slides) by A. M. Buswell; "Micro Dissolved Oxygen Apparatus," (with demonstration) by A. M. Buswell; "Note on the Use of Dyes in Agar Media," by Max Levine; "Use of Gentian Violet Broth," by Jack J. Hinman, Jr.; "A Note on the Voges Proskauer Reaction," by C. S. Linton; and "Organization and Program of Sewage Investigations by the New Jersey Argicultural Experiment Station and the State Department of Health," by William Rudolfs.

The session was largely attended and the discussions of the papers were both general and extensive.

The second session of the Chemical and Bacteriological Division met at 2:00 p.m., on May 21. The first order of business was the report of Committee No. 18, Filter Sand Testing and Recording, of which Paul Hansen is Chairman. Discussion of this report was by F. H. Waring, Abel Wolman and John R. Baylis. Committee

No. 3, Practicable Loadings for Purification Processes was next reported for by S. M. Van Loan. Discussion was by Abel Wolman, S. M. Van Loan, W. Donaldson, H. W. Streeter and F. H. Waring.

An interesting discussion was held on "The Most Interesting Experience I Have Recently Encountered in Water Treatment." This was opened by J. W. Armstrong, and those who spoke were J. R. Baylis, W. R. Gelston, A. V. Graf, F. W. Green, C. R. Henderson, C. P. Hoover, N. J. Howard, H. W. Jordan, M. C. Whipple, L. H. Enslow, and A. M. Buswell.

A dinner for the members of the Chemical and Bacteriological Division was held on Wednesday evening, May 21, in the South Gardens on the tenth floor of the hotel. The toastmaster of the dinner was Almon L. Fales. Mr. Fales first called upon President Fuller and the latter made a long address outlining some suggestions as to the future of the division. Mr. Fuller, among other matters, spoke of the idea of changing the name of the Division to a more comprehensive title and suggested that of "Water Purification and Control Division."

The next speaker was the incoming president, Frank C. Jordan, who outlined his policy and spoke of what he hoped to accomplish for the convention and for the division during the coming association year.

The chairman followed the plan of calling upon the members during the dinner and between courses instead of waiting until the end, and there were a large number of addresses given. Among the speakers were Harry E. Jordan, Jack J. Hinman, Jr., F. W. Green, Malcolm Pirnie, H. Burdette Cleveland, Robert S. Weston, Paul Hansen, J. M. Goodell, George C. Whipple, A. M. Buswell, N. J. Howard and John R. Baylis. The speaking continued until a late hour.

Friday Morning, May 23. Presiding officer, A. L. Fales. The following papers were presented:

"Characteristic Properties of Zeolites for Water Softening," by S. B. Applebaum.

"The Early History of Zeolites," by A. S. Behrman.

Both papers were discussed by A. M. Buswell, L. M. Yoder, J. R. Baylis, S. B. Applebaum and A. S. Behrman.

"Adsorption of Aluminum Hydrate," by L. B. Miller.

The Division was then addressed by President Fuller on the organization and function of the Division in the Association.

Considerable discussion took place on the program of work of Committee No. 1 on Standard Methods of Water Analysis.

W. S. Cramer addressed the Division on the general thought of extending cooperation from the Division of Plant Management and Operation.

In the absence of any opposition, the following officers, suggested by the Nominating Committee, were elected: A. M. Buswell, Chairman; J. W. Armstrong, Vice-Chairman; J. J. Hinman, Secretary; R. C. Bardwell and C. P. Hoover, Executive Committee Members. The decision as to a change in the name of the Chemical and Bacteriological Division was deferred until the next annual convention.

THE HILL CUP FOR MEMBERSHIP

North Carolina retains the Hill Cup, as this section showed by far the greatest percentage of increase in membership for the year ending May 21, 1924. Certain records were lost when the office of the Association moved to its new quarters. North Carolina, however, has by far the greatest increase. Their percentage of increase approximated 87, with the Iowa Section second with 36, and California third with 34.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

War Department Turns to Fuel Oil. W. W. Bowman. Power, 58: 9, 327, August 28, 1923. Three 4400 sq. ft. boilers were converted from coal to fuel oil. This necessitated installation of oil-storage tanks, pumps, and piping; a change in the boiler setting and baffling, and installation of fuel-oil burning equipment. Official acceptance test showed exceptionally low draft required; economically low flue-gas exit temperature; and high gross and net boiler, and furnace efficiency, well sustained over wide range of operation.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, 58: 9, 342, August 28, 1923. Questions are asked and answers given on following subjects,—Position and Durability of Boiler Patches; Steam Valves of Duplex Pumps Without Lap or Lead; Overheated Main Bearing; Hammer Test of Boiler; Cause of High Head Pressure; Percentage of CO_2 for Best Efficiency; Removal of Gas from Well Water; Averaging Readings of Spring Pressure Gage; Cushion of Steam Pump; Negative Lead of Valve.—*Aug. G. Nolte.*

Periodic Power-Plant Inspection. Power, 59: 11, 404, March 11, 1924. The Federal Light and Traction Co., New York City, have issued general instructions to managers of their subsidiary companies for a yearly inspection of all power-station apparatus. A partial list of units to be inspected, for each of which required observations are stated, follows—Turbo-Generator Units; Condensers; Boilers, Stokers and Furnaces; Reciprocating Engine Generator Units; Feed Water Heaters; Water Softeners and Tanks; Cooling Water Facilities; Auxiliaries; Steam and Water Piping; Instruments and Switch-Board Equipment.—*Aug. G. Nolte.*

Largest Two-Stroke-Cycle Diesel Built in America. Power, 59: 11, 406, March 11, 1924. Description of the Bethlehem 2900-horsepower Diesel engine. —*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power, 59: 11, 422, March 11, 1924. Questions are asked and answers given on following subjects: Relative Advantages of Bevel and Flat Seats for Safety Valves; Furnace Volume for Pulverized Coal and for Fuel Oil; Additional Pressure for Increased

Temperature of Air; Unreliability of Distorted Bourdon Gage Tube; Operating Alternator Without Direct-Current Excitation; Boiler Plant Output per Pound of Fuel; Greater Range of Cutoff with Double-Eccentric Engine.—*Aug. G. Nolte.*

Typhoid Fever in the Large Cities of the United States, 1923. Public Health Reports, 39: 8, 349, February 22, 1924. Taken from issue of February 2, 1924, Jour. Amer. Med. Assocn. Statistics of 69 cities that had more than 100,000 population in 1920. Slight typhoid reduction shown in 1923 as compared with 1922. Average death rates per 100,000 from typhoid fever for these cities for the years 1920, 1921, 1922 and 1923 were, respectively, 3.7, 4.0, 3.3 and 3.2. Average death rate per 100,000 for same cities arranged in groups according to population, follow. Group 1, population more than 500,000 (12 cities), rate 2.5 Group 2, population 300,000 to 500,000 (9 cities), rate 3.8; Group 3, population 200,000 to 300,000 (12 cities), rate 4.1; Group 4, population 150,000 to 200,000 (10 cities), rate 6.7; Group 5, population 125,000 to 150,000 (9 cities), rate 2.8; Group 6, population 100,000 to 125,000 (17 cities), rate 4.2. Norfolk, Va., included in last group, had honor of being only city among the 69 without a death from typhoid fever during 1923. Actual percentage reduction of typhoid has slowed up; but improvement in many cities is still taking place. Rural typhoid must now be eradicated.—*Aug. G. Nolte.*

Spring Water of Unusual Composition. R. T. Thompson and James Sorley. Analyst, 49: 82–3, February, 1924. A spring water from a wood near Glasgow contained $Al_2(SO_4)_3$, 38.1 p.p.m; $FeSO_4$, 0.1 p.p.m.; $CaSO_4$, 17.2 p.p.m. $MgSO_4$, 10.7 p.p.m.; $MgCl_2$, 6.1 p.p.m.; NaCl, 25.9 p.p.m; $NaNO_3$, 0.4 p.p.m.; SiO_2, traces; organic matter, 6.0 p.p.m.; total, 104.5 p.p.m. It contained 0.07 p.p.m. albuminoid NH_3; and 0.05 p.p.m. free NH_3.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A New Alloy of Aluminum, "Alpax". Leon Guillet. Le genie civil, 82: 413–419, 441, 1923. An aluminum-silicon alloy containing about 13.5 per cent Si, patented by Pacz, an American metallurgist. Dissolving Si in Al does not give satisfactory results. The Al is heated to about 1000°C. and then Si is added. When temp. is reduced to about 930°C., alkali salts, notably fluorides, are added. Material is mixed and allowed to cool. Si-Al alloys have been known since 1856.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Determination of Dissolved Air in Small Quantities of Water. H. G. Becker and W. E. Abbott. Chem. Ind., 42: 484–6T, 1923. Methods of Letts and Blake and of Winkler for determining dissolved oxygen are not applicable to quantities less than 50 cc. of water. Authors have devised special apparatus and method for small quantities, based upon liberation of air from water when a solid is dissolved. Solid KOH is put in the apparatus, and 20–30 cc. of water drawn in: evolved gas is measured in graduated tube of small bore, passed through pyrogallol, and again measured. A cheaper substitute for the expensive KOH was sought and finally found, in air-free pellets of $(NH_4)_2SO_4$. (Cf. this Journal, 11: 2, 508).—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Corrosion of Aluminum Cooking Utensils. C. Kenneth Tinkler and Helen Masters. Analyst, **49**: 30, 1924. Stains on vessels in which tap water is boiled are due to solution of small amount of Al, leaving behind Fe and other impurities which show black and are not soluble in alkaline water. Stain may be removed by acid. On dissolving Al ware in NaOH, of a residual 2.2 per cent of black powder, all but 0.38 per cent was soluble in HCl.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Determination of Silica in Waters. F. Dienert and F. Wandenbulcke. Comptes rendus de l'Academie des Sciences, **176**: 1478–80, 1923. Waters from same geological formation, even though Ca content may vary, nevertheless possess similar amounts of Si. Sands of Seine allow solution of 3 p.p.m. SiO_2, while those of Loire allow up to 12–14 p.p.m. Gravimetric method is long and inaccurate. Method proposed is based on yellow color formed with molybdate, and determines only the dissolved SiO_2, not the colloidal material. The silicomolybdate only forms with ordinary molybdate reagent on heating; but with Meillere's reagent, $(NH_4)_2MoO_4$, H_2SO_4 and HNO_3, in cold. More rapid results are obtained with molybdate and H_2SO_4 alone. *Procedure*: Take 50 cc. of water, add 2 cc. 10 per cent $(NH_4)_2MoO_4$ and 4 drops 1:4 H_2SO_4. Compare with standards made similarly with Na_2SiO_3, or with picric acid, of which a solution containing 36.9 mgm. per liter corresponds with a solution containing 50 p.p.m. SiO_2. Maximum amount of SiO_2 for 2 cc. of 10 per cent $(NH_4)_2$ MoO_4 is 60 p.p.m. Colloidal state of silica may be destroyed by heating on water bath with 0.2 grams $NaHCO_3$ for each 50 cc. of water. Since this solution attacks glass or the glaze of porcelain, the heating should be done in Pt dishes. Acidify with 2.4 cc. N/1 H_2SO_4 and treat as above after cooling. Water contains less dissolved SiO_2 after filtration.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Campaign against Corrosion of Boiler Plates by Removing Gases from Water. Henri Marchand. Le Genie Civil, **82**: 423–5, 1923. The amount of O dissolved in water varies with origin, temperature, exposure to air, agitation, etc. Temperature is very important; the solubility varying from about 10 cc. per liter at 0°., to zero at 100°, being about 1 cc. at 90°. Harmfulness of water depends chiefly on temperature, as gas becomes more active as temperature rises. Below 60°, 1 cc. of O per liter is allowable; but at 75–80°, not over 0.5 cc. At 150°, active corrosion results if O present exceeds 0.2 cc. De-activation is most important for high temperatures. Processes of deactivation are: (1) Chemical. Water is passed through apparatus containing oxidizable metal, at as high a temperature as possible, and then filtered to remove $Fe(OH)_3$. If previously rendered slightly alkaline, by passing through granular MgO, better results are obtained. (2) Mechanical. Agitation under diminished pressure removed about 80 per cent of O. Heating to 90–95°, even at ordinary pressures, reduces the O to 0.4 cc. per liter. In some installations, water is first heated to remove O and then put through chemical de-activator.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Mechanical Filtration (Elimination of iron from water). W. H. MAXWELL. Water and Water Eng., 25: 401–3, 1923. Description of iron-removal plant at Waltham Abbey, with 12 Candy filters and 2 mgd. capacity. Deep chalk well supply contains iron in amounts varying from 0.65 up to 35 p.p.m. Filters contain 6 inch layer of "polarite", purpose of which is to occlude air for oxidation of the Fe. Plant removes 99.5 per cent of Fe.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Boiler Feed Water Circuits. JAMES WEIR. Water and Water Eng., 25: 1923. Impurities may get into boiler feed water:—(*a*) by leakage into condenser system; (*b*) with the make-up water ; (*c*) in feed water reservoir, by absorption of gases and air. Two methods are used to avoid the last difficulty: (1) the closed system, from which air is excluded; and (2), the deaëration system, in which the feed water is heated to drive off dissolved air. The closed system is not as successful as anticipated. Elastic air cushion in feed tank is absent, and constant level is not maintained. A common practice is to "seal" the tank by means of a small amount of escaping steam, which condenses very rapidly. The reservoir is virtually no more than an enlargement in the feed pipe.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Feed Water Problems. ANON. Water and Water Eng., 25: 408–410, 1923. Few lime-soda plants soften below 80 p.p.m., and few filters take out more than 80 per cent of the deposit. Soda makes part of the chalk colloidal and filters are ineffective against this. Heat economizers or boilers change the colloidal matter to ordinary scale. "Algor" is a proprietary colloidal substance, used for treatment of boiler feed water. Feed water should have pH of over 9 (pure water has pH of 7.)—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Utilization of Springs. DIENERT. Rev. Hyg., 45: 1128–1148, 1923. A summary of practice, bringing up to date report made in 1911. Contains concise statement of properties required in a good potable water. Discusses sanitary surveys and interpretation of results. *Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Determination of the Sulfate Ion by Precipitation as Barium Sulfate. K. P. CHATERJEE. Z. anorg. allgem. Chem., 121: 128–34, 1922. From Chem. Abst., 16: 2821, September 10, 1922. In precipitating sulfate with barium chloride, excess hydrochloric acid, up to a certain limit, causes more positive error due to absorbed chloride than excess barium chloride by itself. Solution should not contain more than 0.1 per cent hydrochloric acid by volume.—*R. E. Thompson.*

Some Geological and Biological Effects of Sulfate-Bearing Solutions on Humus Waters. A. G. HÖGBOM. Bull. Geol. Inst. Univ. Upsala, 18: 239–61, 1922. From Chem. Abst., 16: 2830, September 10, 1922. After dry summer of 1914, many Swedish lakes sank very low, exposing post-glacial soil rich in sulphides, which were oxidized to efflorescent sulphates. When lakes rose again, suphates were dissolved, and caused precipitation of humus compounds, affecting plants and fish.—*R. E. Thompson.*

Action of Salt Solutions on Mild Steel. J. A. Jones. Chem. Trade J., **70**: 323–5, 1922. From Chem. Abst., **16**: 2836, September 10, 1922. One of chief factors in production of cracks is presence of either internal or applied stresses which must exceed certain definite values. From experiments with salt solutions, it was concluded that solutions of nitrates yielded a product having such action on intercrystalline material that intercrystalline cohesion is reduced.—*R. E. Thompson.*

Some Causes of Rejections in Boiler Tubes. H. C. Carter. Chem. Met. Eng., **26**: 1113, 1922. From Chem. Abst., **16**: 2836, September 10, 1922. Chief causes of rejections are: crookedness, non-uniformity of wall thickness, seams, tears, excessive scale, and brittleness, as shown by expanding, flattening, or hydraulic pressure tests. These defects are discussed.—*R. E. Thompson.*

Study and Report on Pitting and Corrosion of Boiler Tubes and Sheets. Character of Metal, Methods of Manufacture, Construction of Boilers, and Quality of Water Considered. Anon. Committee Report, Am. Railway Eng. Assoc. Bull., **243**: 493, 1921. Railway Age, **72**: 689, 1922. From Chem. Abst., **16**: 2836, September 10, 1922.—*R. E. Thompson.*

Mechanical Lubricators. A. B. Smith. Diesel Engine Users' Assoc., February 10, 1922. From Chem. Abst., **16**: 2943, September 10, 1922. Numerous diagrams of lubricators given: deficiencies and advantages discussed. Most difficult task of lubricator is to deliver oil in small quantities against high pressure.—*R. E. Thompson.*

Chlorination of Municipal Water Supplies. Jos. Race. J. State Med., **30**: 263-6, 1922. From Chem. Abst., **16**: 2945, September 10, 1922. History of development of chlorination given. "Aftergrowths" develop as secondary cycle with bleach and liquid chlorine. At Denver, Colo., "aftergrowths" entirely disappeared when chloramine was substituted.—*R. E. Thompson.*

Rain Water. P. de Sornay. Rev. agr. Maurice, **1**: 78, 1922. From Chem. Abst., **16**: 2945, September 10, 1922. In Mauritius, rain contains 2.14–4.11 mg. SO_3, 3–4.57 mg. chlorine, and 1.45–1.70 mg. nitrogen per liter.—*R. E. Thompson.*

Correlation of Stream Pollution Criteria from Studies on Naugatuck and Hocanum Rivers in Conn. J. F. Jackson. Am. J. Pub. Health, **12**: 124–33, 1922; Pub. Health Eng. Abst., April 15, 1922. From Chem. Abst., **16**: 2945, September 10, 1922. Chemical and bacteriological analyses did not show definite correlation between appearance and actual condition of water, owing to varying character and form of suspended solids. Acids and calcium salts affected bacterial content. Owing to inhibitory effects of wastes, dissolved oxygen and dissolved oxygen demand tests could not be used as indices of pollution. The dilution factor is discussed.—*R. E. Thompson.*

Behavior of Concrete in Solutions of Ammonium Salts. R. Grün. Zement, **10**: 425–6, 1921. From Chem. Abst., **16**: 2974. September 10, 1922. Concrete should be protected from ammonium salts, which have detrimental action similar to that of acids, acid radicals in salts combining with lime, forming soluble salts, and liberating ammonia.—*R. E. Thompson.*

Tests on Absorptive Qualities of Cement Blocks. Stanton Walker. Eng. News-Rec., **88**: 282–4, 1922. From Chem. Abst., **16**: 2974, September 10, 1922. Absorption varies inversely with strength; increased by using more water with mix; decreased by using coarser aggregates, increasing quantity of cement, or storing specimens in moist place immediately after molding. With quantity constant, absorption decreases as density increases. By varying quantity and with other factors constant, absorption decreases as density decreases.—*R. E. Thompson.*

The Determination of Tar Acids and Tar Bases in Road Drainage and Mud. J. J. Fox and A. J. H. Gauge. J. Soc. Chem. Ind., **41**: 173T, 1922; cf. C. A. **14**: 3041. From Chem. Abst., **16**: 2974, September 10, 1922. Solutions of small quantities of tar acids or bases, if in non-sterile water, should be analyzed as soon as possible to avoid loss by biological change; in one case amount of tar acids present diminished in 2 days to 25 per cent of original value.—*R. E. Thompson.*

Resistance of Cement Mortars to Abrasion. H. Nitzche. Zement **11**: 65–6, 79–81, 99–102, 1922. From Chem. Abst., **16**: 2975, September 10, 1922. Blast furnace slag cements behaved best, while iron portland cements were least resistant. Hydraulic modulus appeared important but there was no apparent connection between kind of sand used and resistance to abrasion.—*R. E. Thompson.*

The Significance of Fuel Losses Through Incomplete Combustion of Low-Grade Coals. F. Ebel. Glückauf, **58**: 739–44, 1922. From Chem. Abst., **16**: 2977, September 10, 1922. Most important loss is combustible material remaining in ash. Flue losses and losses through formation of carbon monoxide are of secondary importance.—*R. E. Thompson.*

Some Characteristics of Petroleum Oils Used in Diesel Engines. H. Moore. Diesel Engine Users' Assoc., April 7, 1922. From Chem. Abst., **16**: 2984, September 10, 1922. Extensive discussion. Eight tests of fuel oils are suggested as being of greatest importance: specific gravity, closed flash point, cold test, heat value, ash content, water content, coke value, and content of hard ashaltum. Design of engines greatly affects their capability of burning heavy oils, 4 predominating factors being speed of engine, compression pressure, maximum mean effective pressure at which engine will run, and type of injection (blast air or mechanical).—*R. E. Thompson.*

Water in Relation to Dyeing. John MacGregor. Color Trade J., **9**: 43–8, 1921. From Chem. Abst., **16**: 2998, September 10, 1922. Discussion of

difficulties which may occur when impure water is used with various classes of dyestuffs.—*R. E. Thompson.*

The Purification of Water Used in Washing Coal. K. Imhoff. Glückauf, 58: 776–8, 1922. From Chem. Abst., 16: 2977, September 10, 1922. Present methods of purifying water after coal washing, with subsequent recovery of coal sludge, discussed. Most economical processes are based on sedimentation.—*R. E. Thompson.*

Surface Tension Phenomena and Electrostatics. R. H. Jarvis and D. W. Leeke. Eng. Mining J. Press., 114: 17–8, 1922. From Chem. Abst. 16: 3244, October 10, 1922. Particles on liquid surface which are wetted attract each other, but are repelled by dry particles. Particles which are wetted by water are attracted by positively charged hard rubber rod, while particles not wetted are repelled.—*R. E. Thompson.*

Entrainments by Precipitates. P. Dutoit and Ed. Grobet. J. Chim. Phys., 19: 328–30, 1921. From Chem. Abst., 16: 3245, October 10, 1922. Clean separation of calcium and magnesium as oxalate, barium and calcium as sulfate, and barium and strontium as chromate, can be effected by vigorous mechanical stirring during addition of precipitant and by adding reagent dropwise at point of maximum agitation.—*R. E. Thompson.*

Intercrystalline Cracking of Mild Steel in Salt Solutions. J. A. Jones. Trans. Faraday Soc., 17: I, 102–9, 1921. From Chem. Abst., 16: 3292, October 10, 1922. Property of inducing rapid cracking in stressed mild steel has been observed in case of solutions of sodium, potassium calcium and ammonium nitrates. Similar action of solutions of caustic alkalies is well known.—*R. E. Thompson.*

Strength and Elasticity of Boiler Plates at Elevated Temperatures. H. J. French. Chem. Met. Eng., 26: 1207–9, 1922; cf. C. A., 16: 1384, 1927. From Chem. Abst., 16: 3299, October 10, 1922. Proportional limit is maintained or increased with first temperature rise, and tensile strength has slight maximum about 250°; but both fall off badly at higher temperatures. Reduction and elongation have minimum about 260° but recover original value around 450°.—*R. E. Thompson.*

Corrosion; with Special Reference to the Ferrous Metal and the Deteriorations of Ships. A. Pickworth. Electrician, 89: 100-1, 1922. From Chem. Abst., 16: 3299, October 10, 1922. General survey, and some of methods of retardation and prevention now employed.—*R. E. Thompson.*

Corrosion of Brasses and Bronzes by City Water Supply of Buenos Aires. A. A. Bado and R. A. Trelles. Anales asoc. quim. Argentina, 10: 16–9, 1922. From Chem. Abst., 16: 3300, October 10, 1922. The water contains no unusual constituents, and is slight alkaline owing to bicarbonates. Typical

brasses and bronzes containing only copper, tin, zinc, lead, and iron were suspended in the water for 702 days; loss in weight varied from 14 to 19 mgm. per sq. cm.—*R. E. Thompson.*

High Pressure Steam, up to Sixty Atmospheres, in Power and Heat Economy. O. H. Hartmann. Z. Ver. deut. Ing., **65**: 663–71, 713–9, 747–53, 848–52, 998–93, 1047–8, 1921. From Chem. Abst., **16**: 3351, October 10, 1922. Summary of experiments made by Wilhelm Schmidt in 1911–14, and 1916–18.—*R. E. Thompson.*

Control of Causticizing Lime by Determining Active Lime Content. G. K. Spence. Paper Industry, **3**: 1095–7, 1921. From Chem. Abst., **16**: 3365. October 10, 1922.—*R. E. Thompson.*

Preparation of an Aqueous Standard Soap Solution for Determining the Hardness of Water. Ed. Justin-Mueller. J. pharm. Chim., **26**: 18–21, 1922. From Chem. Abst., **16**: 3354, October 10, 1922. Clark's soap solution, modified by Boutron and Boudet, is rendered more sensitive by being made 0.1 stength. Solution is simpler to prepare and avoids use of ethyl alcohol. Boil 3.5 g. Marseilles soap with 200 cc. water: when clear, add water to make 900 cc. and filter through cotton. Standardize with calcium chloride (0.25 g. in 1000 cc.) or barium nitrate (0.59 g. in 1000 cc.)—24 cc. soap solution = 40 cc. of calcium or barium solution, corresponding to 2.4 cc. = 22° Boutron and Boudet's solution. Using 40 cc. water, pure water requires 2 cc. to persistent foam: temporarily hard water, after boiling and filtering, retains precipitated calcium carbonate equivalent to additional 3 cc. soap solution. Hence no. cc. − 2 = no.° total hardness, and no. cc. —5 = no. ° permanent hardness.—*R. E. Thompson.*

Chemical Studies of Swimming Pool Water. Roy. W. Goshorn. Hahnemannian Monthly, **57**: 460–9, 1922. From Chem. Abst., **16**: 3354, October 10, 1922. Chlorides, and nitrogen in all forms examined, were in greatest quantities in pool used exclusively by women, nitrogen as urea being 10 times as great. Chlorides, and nitrogen as free ammonia and as nitrates, were higher in pools without filtration. Filtration did not affect urea content. Copper sulfate treatment had no effect on chloride and nitrate content. Possible explanation of results, in fact that women wore bathing suits during preliminary shower and bathing period, while men did not.—*R. E. Thompson.*

Selection and Treatment of Waters for Spraying Purposes with Special Reference to Santa Clara Valley. E. R. De Ong. California Agr. Expt. Sta., Bull., **338**: 301–14, 1921. From Chem. Abst., **16**: 3361, October 10, 1922. General discussion of water softening. Hard water forms dangerous combinations with, or destroys efficiency of, many forms of insectides. Water containing 20 p.p.m. Cl reported as dangerous to use with acid arsenate of lead. Basic arsenate of lead should be used with hard or alkaline waters.—*R. E. Thompson.*

Alum and Its Analysis. James Scott. Paper-Maker, Brit. Paper Trade J., 63: 629–30, 1922. From Chem. Abst., 16: 3366, October 10, 1922. Alum is tested for iron, insoluble matter, alumina content, and acidity. Best grades contains less than 0.00025 per cent iron; second quality less than 0.2 per cent; and third, used for colored papers and water purification, ranges above that amount.—*R. E. Thompson.*

Some Causes of Cracking and Disintegration of Portland Cement Concrete. R. E. Stradling. Concrete and Constr. Eng., 17: 393–8, 475–80, 1922. From Chem. Abst., 16: 3373, October 10, 1922. Reasons for cracking and disintegration numerous, not well defined, and, in many cases, not understood. By far the greater number of failures due to faulty workmanship, or conditions to which work is exposed. Only few cases can be traced to poor material.—*R. E. Thompson.*

Disintegration of Cement Tile in Peat. F. J. Alway. J. Am. Peat. Soc., 15: 3, 15–25, 1922. From Chem. Abst., 16: 3374, October 10, 1922. Four main causes are: (1) Humic acids, which remove lime. These cause greater damage in swiftly moving water, since in quiet water, coating of insoluble calcium humate is formed and protects cement. (2) FeS_2, either as pyrite or marcasite, which, on exposure to oxygen and moisture, oxidizes to ferrous sulfate and sulfuric acid, both of which remove lime. (3) Hydrogen sulfide, which reacts with lime cement to form calcium sulfide, then sulfhydrate and sulfate. (4) Alkali water, which contains sodium sulfate, magnesium sulfate, and magnesium chloride. These react with lime to form either soluble compounds, or those having larger molecular volumes.—*R. E. Thompson.*

Determination of the Hardness of Water for Technical Purposes. G. Weissenberg. Z. angew, Chem., 35: 177–179, 1922. Chem. Ind., 43: B 150, 22 February, 1924. Tables are given comparing hardness of a number of samples of water as determined by gravimetric analysis, by Winkler's potassium oleate method (Lunge-Berl Chem. techn. Untersuchungsmeth. 4 Aufl. 2, 234) by Blacher's potassium palmitate method (J. 1912, 555, 1913, 158), and by the modified soap method (Z. angew, Chem., 1913, 26, 140). Potassium oleate method gives reliable results only in case of water with low degree of hardness, and containing no excess of magnesium salts, such as purified water; results are affected only to slight extent by presence of free carbon dioxide. Results obtained by potassium palmitate method are reliable in presence of neutral salts, but are unreliable if free carbon dioxide present. Free carbon dioxide, however, can be removed by neutralizing with dilute hydrochloric acid, using methyl orange or methyl red as indicator, blowing air through solution and then making faintly alkaline by addition of 2 drops alcoholic sodium hydroxide solution. Solution is then titrated with potassium palmitate in presence of phenolphthalein. Potassium palmitate method gives reliable results with waters having moderate or high degree of hardness; if carbon dioxide removed, it can be used for natural and purified waters. Modified soap method gives the most accurate results and is the most suitable for rapid determination of hardness of all waters used for technical purposes (L. A. C.).—*A. M. Buswell.*

Removal of Iron from Drinking Water. KISSKALT. Gas-u. Wasserfach, 1924, 67: 3–4. Chem. Ind., 43: 12, B 23. March 21, 1924. A number of processes have been described in which iron is removed from water by aeration effected by allowing water to flow down towers packed with coke, or by spraying it through nozzles. In this way iron is oxidized to the hydroxide, which remains in colloidal solution until it is coagulated and removed by the action of the material forming the filter bed. Too much aeration is to be avoided if water contains a relatively large proportion of lime and carbon dioxide, else latter may be driven off, leaving insufficient to hold the lime in solution as bicarbonate, with result that calcium carbonate is precipitated and blocks the pipes. (Cf. C I., 1923, 343 A.).—*A. M. Buswell.*

Titration of Hydroxyl and Carbonate Ions in the Presence of One Another in Drinking Water. K. SCHERINGA. Pharm. Weekblad, 61: 113–115, 1924. Chem. Ind., 43: 12, B231, March 21, 1924. The titration and calculation by the standard method, namely two separate titrations, using phenolphthalein and methyl orange respectively as indicators, may be simplified, when water is alkaline to phenolphthalein, by titrating first with latter and then with methyl orange as indicator in same solution. If amounts of acid used in each case are the same, only CO_3'' ions are present; if more is required with methyl orange, HCO_3' ions, but no OH' ions are present; if less is required, OH' is present. The calculation is carried out by simple arithmetic.—*A. M. Buswell.*

Creamery Waste Purification by Means of Activated Sludge. M. LEVINE. Eng. News-Rec., 92: 152, 1924. Chem. Ind., 43: 12, B231, March 21, 1924. Experiments on small scale at Iowa State College, Ames, Iowa, have shown that creamery wastes can be satisfactorily purified by activated sludge process. Using 2 per cent skim milk, an activated sludge was prepared in 2 weeks, and marked reductions in turbidity, acdity, total solids, organic mitrogen, and particularly in oxygen consumed and demand, were obtained with an aëration period of 16–25 hrs. when employing 20 per cent of sludge and 50–60 cub. ft. of air per gal. The reduction in oxygen requirement was generally 95–98 per cent. With partially activated sludge, aeration periods of 6 hrs., and 15.6 cubic feet of air per gal., an average reduction of 43.9 per cent of solids, 77.7 per cent of organic nitrogen, and 76 per cent of oxygen consumed and demand was obtained. A further reduction of 20 per cent, together with a reduction in air requirements to 11.4 cub. ft. per gal., was obtained by extending aëration period to 12 hours. Buttermilk was more readily purified than skim milk. With better distribution of air, improved results are anticipated; elimination of 95 per cent of the oxygen-requiring constituents from 2 per cent skim milk or buttermilk was not sufficient to yield stable effluents. Aëration of 2–3 per cent skim milk with activated sludge for 4 hrs. was found sufficient to produce effluents which would not become appreciably acid under anaërobic conditions, and probably suitable therefore, for admixture with sewage in septic tanks.—*A. M. Buswell.*

Process of Treating Sewage Sludge. MACLACHLAN REDUCTION PROCESS CO., INC., Assess. of A. Maclachlan. E. P. 196, 239, 12.7.22. Conv., 12.4.22. Chem. Ind., **43**: 12, B231, March 21, 1924. Activated sludge is treated with sulphur dioxide gas alone, or with a mixture of sulphur dioxide and steam, until gelatinous solid constituents are completely granulated. Sludge is then allowed to settle, supernatant water removed by decantation, and residue passed to filter-beds, filter-presses, or the like, to be further dewatered. Treatment with sulphur dioxide in manner described facilitates considerably dewatering and drying of the sludge, retards putrefaction, and conserves nitrogen. Final product may contain 75 per cent more nitrogen than product from untreated sludge, and 40 per cent more then that from sludge treated with acids —*A. M. Buswell.*

Effects of Storage on Artificially Polluted Waters. R. C. FREDERICK. Analyst, **49**: 63–73, 1924. Chem. Ind., **43**: 14, B–274, April 4, 1924. Bulk quantities, distilled from all-glass apparatus and free from ammonia, were treated with fresh suspension of soil taken from underneath growing turf in order to reproduce character of natural water, and were polluted with 1 part in 22,000 of urine, of feces, and of mixture of equal parts of urine and feces. The quantities were then divided into samples of exactly similar original composition, which were filled into stoppered bottles, which were set aside under predetermined conditions and their contents analyzed after various periods of storage, up to 100 days, for free ammonia, albuminoid ammonia, nitrites, and nitrates. In samples stored in dark at ordinary temperature, the chemical changes took place comparatively slowly, and quite different results were obtained according to whether the pollution was urinary, fecal, or a mixture of both. The analytical results, which are given in a table, completely disprove the view that the chemical evidence of excretal pollution in water disappears rapidly on storage, and show that, if pollution of the supply has only been very recent, the evidence in samples would be more pronounced if the analysis were actually delayed for a considerable period. The quantity of albuminoid ammonia found was at no time a small fraction of that of the free ammonia; it was seldom appreciably less and was frequently larger than the quantity of free ammonia. A statistical consideration of the analyses of nearly 1000 samples of every kind of water supply showed that, of waters considered potable, none contained free ammonia in excess of 0.003, albuminoid ammonia in excess of 0.008, or nitrites in excess of 0.0001 pt. per 100,000 after excluding samples which could have derived these substances from other than excretal sources.—*A. M. Buswell.*

Formation of Methane from Sewage Sludge. BACH AND SIERP. Zentr. Baktr. u. Parasitenk., II Abt., **60**: 318–328, 1923. Chem. Zentr. **95**: I., 369–370, 1924; Chem. Ind., **43**: 14, B–275, April 4, 1924. Decomposed sludge from septic tanks contains methane bacteria, and considerable quantities of gas containing methane, carbon dioxide, and nitrogen may be obtained from it. It can also be used to ferment calcium acetate, whereby calcium carbonate, methane, and carbon monoxide are obtained. Hydrogen is never obtained by the further decomposition of the sludge; its occurrence must be ascribed to

presence of more recent sludge. By repeated decantation of decomposed sludge, mixed with nutrient inorganic material and with calcium acetate solution, a preparation is obtained which sets up methane fermentation more quickly and energetically than untreated sludge. Presence of nitrogen in gas from sludge fermented in presence of calcium acetate is due to breakdown of organic nitrogen compounds and not to denitrification of nitrites, and the undiminished nitrogen content in gas from sludge which has been repeatedly fermented must be ascribed to decomposition of dead bacteria. Presence of nitrites may inhibit, partially or completely, methane fermentation. Concentration of bacteria has marked influence on rate of fermentation, and a certain minimum of decomposed sludge is necessary for its continuance.—*A. M. Buswell.*

Electro-Osmotic Process for the Partial or Complete Purification of Water. Elektro-Osmose A. G. (Graf Schwerin Ges.). G. P. 383, 666, 11.9.21. Chem. Ind., **43**: 14, B-275, April 4, 1924. Water to be freed partially or completely from salts is submitted to action of an electric current between diaphragms arranged so that diaphragms nearest positive and negative poles become respectively positively and negatively charged. Preferably, water is sprayed in thin sheet into middle chamber of a three compartment apparatus, and is therein submitted to action of current as described. The spray is preferably directed in direction of migration of substances to be removed. Water can, in this manner, be purified to any degree for electrolysis, and completely freed from living organisms.—*A. M. Buswell.*

The New Rapid Sand Filtration Plant at Cambridge, Mass. Geo. A. Johnson. Amer. City, **30**: 241–246, 1924. (From paper before N. Eng. W. W. A.) Filtration works of 14 mgd. nominal capacity were put in full operation on April 25, 1923. Supply is from two impounding reservoirs, Hobbs Brook, of 2,500 mg., and Stony Brook, of 400 mg. capacity; latter being fed along natural drainage channel from former. Aqueduct consisting of 1.42 miles of 30-inch C. I. pipe, 0.91 mile of 36-inch pipe, 5.2 miles of 63-inch concrete conduit and 0.36 mile of C. I. pipe brings the water by gravity from lower, or Stony Brook, reservoir to filtration plant. Excess water is by-passed over weir into Fresh Pond, holding 400 mg., which is used only as reserve for high peaks, and necessitates pumping. Drainage area above diversion point is 23.57 sq. mi., with resident population of 120 per sq. mi. Hardness of raw water ranges from 20 to 40, with average about 30 ppm.; color ranges 20 to 50, with average about 25. Turbidities are low. Purification plant consists of covered coagulating basin, 10 rapid sand filters, filtered water aërator, clear water basin, sterilizing equipment, wash water receiving basin, and low-lift pump. Coagulating 137 x 96 x 16 ft. deep, has retention of 2.5 hours at full capacity, and is divided by longitudinal wall into two compartments. Ten filter units of concrete construction are arranged in single row. Each filter has 480 sq. ft. sand. area, equivalent to 1.4 mgd. Filters have Wheeler bottoms, 9 inches graded gravel, and 27 inches sand. Filtered water is aërated; dosed with chlorine; then flows to covered clear basin of 4.0 mg. capacity; thence to high service pumps. Special features are, (a) arrangement for retaining filter wash water

and returning to coagulating basin, in order to conserve wash water and accelerate coagulation; and (b) device for aërating filtered water, consisting of sloping concrete slabs with imbedded herringbone baffles. Sulfate of alumina, applied as solution, is the coagulant. Soda-ash is used to compensate for deficient alkalinity during freshet stages. Itemized cost of improvements is given, amounting to total of about $768,000 of which $607,000 was properly chargeable to filter plant.—*W. Donaldson.*

The Public Works of the New Model Town, Mariemont, Ohio. R. W. Horne. Amer. City, 30: 247–250, 1924. New suburb of Cincinnati is being provided with water supply, sewers, storm drains, and paving. Water supply is taken from Cincinnati mains. Local system consists of 14 miles of supply and distribution mains, 6 to 12-inch C. I., and 3 miles of $\frac{3}{4}$-inch brass service pipe, latter being selected because of stated corrosive action of local water. Cost of water system complete was $209,000.—*W. Donaldson.*

The Water Works of Greenville, Miss., Put on a Paying Basis. E. M. Foster. Amer. City. City, 30: 267-270, 1924. Methods are described by which yearly operating expenses of a municipally owned water works, supplying population of 11,000, were reduced from $52,000 to $20,000. By leak inspections, metering 45 per cent of consumers, and reducing pressures from 60 to 40 lbs., consumption was reduced from 3.0 mgd. to 1.6 mgd. with further probable decrease by metering to 1.0 mgd. Former supply system involved pumping well by air-lift into reservoir from which water was repumped directly to distribution, air compressors and centrifugal pumps being electrically-driven but with steam reserve. This has been supplemented by two new Layne & Bowler wells, equipped with motor-driven vertical shaft pumps delivering direct to distribution against 40 lbs. pressure. Wells are 525 ft. deep upper 82 feet being 24-inch, to accommodate pump which is set 80 feet below surface, while lower casing is 10-inch. Wells have wire wound screen. Automatic regulating valve on pump discharge maintains 40 lbs. pressure on mains, pump pressure being 20 to 60 lbs. higher. Comparative six day tests showed air-lift to require 1.86, and Layne system 1.10 K.W.H. per 1,000 gallons, pumped; which, at $2\frac{1}{2}$ cents, equals saving of $7,250 per annum.—*W. Donaldson.*

Improvements in the Water Supply of Ogden City, Utah. B. B. Brewster. Amer. City, 30: 279-281, 1924. Supply is from 34 flowing artesian wells, 4-inch and 6-inch casings, and 120 to 200 ft. deep. Inadequacy of artesian supply to meet growing demand has been met by equipping all wells with air-lift in 1922–23: equipment comprising five single stage compressors, each with 50 H.P. motor drive, also booster pump, for supplying water for cooling and lawn sprinkling. Air-lift has augmented the well deliveries and decreased the draw-down by 3 ft. since pumping operation started.—*W. Donaldson.*

Unique Method of Repairing Large Water Mains. Anon. Amer. City, 30: 281, 1924. A cracked 48-inch water main in Baltimore was welded in place by portable electrical equipment mounted on truck, at cost of $305, as against estimated cost of $1,040 by usual replacement methods. Only necessary to expose and drain main below crack.—*W. Donaldson.*

Water Meters in Chicago. Anon. Amer. City, 30: 297, 1924. According to 47th An. Rep. of Dept. of Pub. Wks. for year 1922, 1471 additional meters were set, bringing total to 32,034. Average maintenance cost was $4.18.—*W. Donaldson.*

How Should Water Taste. John R. Baylis. Amer. City, 30: 365–368, 1924. (Paper before Amer. Soc. for Municipal Improvements.) Plea for more attention to good tasting quality of public water supplies. Palatability of Baltimore supply has been improved by increase in capacity of impounding reservoir, decrease of chlorine dose, better purification efficiency, and control of micro-organisms. Properties of water affecting taste, such as mineral salts, iron, organic content, micro-organisms, corrosion, chlorination, and trade wastes, are discussed, together with remedies available. Pure palatable water can be supplied at reasonable cost if public insists.—*W. Donaldson.*

Water Meters in Philadelphia. Anon. Amer. City, 30: 372, 1924. Annual Report for 1923 shows 11, 881 meters placed during that year, bringing total to 114,000, as against 281,000 unmetered services, thus making a 29 per cent metered city. Practically half of the $5,833,000 water rent receipts are from metered services. Meters are owned by householders, and repaired by Bureau at owner's expense.—*W. Donaldson.*

How Should Hydrant Rentals be Charged in a Municipal Plant? W. C. Brockway. Amer. City, 30: 397–8, 1924. Compensation for fire protection services out of general tax fund, through hydrant rental charge, is more equitable than having cost absorbed in charges for general water consumption; though hydrant rentals usually do not cover entire cost of fire protection services.—*W. Donaldson.*

Planning a Water Works System. Anon. Amer. City, 30: 409–12, 1924. Excerpts from pamphlet by Cast Iron Pipe Publicity Bureau call attention to value of good water works system and give sound advice as to procedures, to towns contemplating public supply works, covering engineering services, selection of sources, water requirements, pumping, duplication of equipment, storage capacity, distribution system, pipe laying, metering, fire hydrants, records, and choice of officials.—*W. Donaldson.*

Warning.—Spring Floods May Contaminate Water Supplies. Amer. City, 30: 443, 1924. Bulletin of New York State Dept. of Health warns of special danger to water supplies incident to spring run-off, and urges that special precaution be taken to meet such overload conditions.—*W. Donaldson.*

The Removal of Iron From the Public Water Supply of Shelby, Ohio. Philip Burgess. Amer. City, 30: 468–70, 1924. Private Water Company at Shelby, though treating an iron-bearing well water with fairly satisfactory results since 1905, has installed new plant of modern design and more adequate capacity of nominally 1.0 mgd., comprising two new dug wells, 45 ft. deep, which replace former drilled wells, a pumping station, and iron removal plant.

Motor-driven centrifugal pumps deliver water to purification plant, where it is distributed by perforated pipe over aerating device, consisting of three superimposed trays located over one end of settling basin. Trays are 4.5 x 9 ft. in plan, giving effective area of 40.5 sq. ft.; are each 12 inches deep, and are spaced 12 inches apart. Wire screen, 3½ inch mesh, forms bottom of each tray and supports coke layer, ½ to 3 inch size. Aërated water drops into settling basin of one hour's nominal retention; thence passes to two gravity filters of 240 sq. ft. sand area each, designed for rate of 100 mgd. Filters have cast-iron manifolds with 1½-inch perforated C. I. laterals. Filter bed consists of 12-inch gravel layer $\frac{1}{12}$ to 2 inch, and 24 inches sand of effective size 0.49 mm. Filters are washed by standpipe pressure, at rate 20 to 24 inches vertical rise per minute. Filtered water storage of 0.25 mg. is provided underneath filters. Raw water contains 6 to 16 p.p.m. iron, 40 to 50 p.p.m. CO_2, and no dissolved oxygen: aërated water contains 20–30 p.p.m. CO_2 and 65 per cent oxygen saturation; filtered water contains 10 to 15 p.p.m. CO_2, and 0 to 0.3 p.p.m. dissolved iron. Author draws following conclusions from operation experience; (*a*) Aërator has important function, and must be cleaned at intervals to avoid clogging with iron, which results in loading filters and poor efficiency (b) Settling basin is useful in removing substantial amount of iron as sludge. (c) A loading of 10 gals. per sq. ft. per minute on coke aërator would be better than 17 gals., for which it was designed. (*d*) Deeper gravel layers than 12 inches, in filters, are desirable, to obviate gravel shifting. Improved quality of water supply has pleased consumers, gained a rate increase for the company and well justified the plant cost of $35,000.—*W. Donaldson.*

Improvements in the Water Works Power Plant, Dubuque, Iowa. L. J. Jellison. Amer. City, 30: 470, 1924. With a voted bond issue of $325,000 for water works improvements, Dubuque is building new fireproof pumping station, of brick and concrete construction, with steel roof truss covered with tile, window frames and sashes of steel, and concrete floor. New equipment includes boilers, pumps, and motor-driven air compressors, for increasing output of artesian wells from 1 to 5 mgd.—*W. Donaldson.*

Copper Sulfate Treatment of a New England Water Supply. E. Sherman Chase. Amer. City, 30: 488–493, 1924. (From paper before New England Water Works Assn.) Description of unfiltered water supply at Rockport, Mass., 30 miles northeast of Boston, and remedial treatment used. Supply is from Cape Pond, a natural body of water about 3,200 ft. long, 600 ft. average width, maximum depth of 23 ft., having total capacity of 182 mg., of which 85 mg. is available. Watershed comprises 222 acres, mostly forested. Intake pipe taps deepest part of pond. Complaints relate principally to odors and tastes from microscopic organisms, though corrosion and red water troubles exist. Predominant organisms are Asterionella, Tabellaria, Anabaena, and Dinobryon. Tastes and odors were substantially controlled by applications of copper sulfate May 22, May 27 and Nov. 3, 1922, and Aug. 14, 1923, the doses being 2¼, 5, 4¼, and 6 lbs. per million gals., respectively. Dosing was done by towing sack behind rowboat. White perch were killed by second treatment

and shallow-water minnows by fourth treatment. Full effect of copper treatment not reached until many days after dosing. Flushing of watermains after copper treatment caused improvement in water delivered to consumers.—*W. Donaldson.*

The Application of Aërial Surveying to Water Supply Problems. C. G. Drueger. Amer. City, 30: 493–4, 1924. Surveys by aërial photography have advantages over other methods, for preliminary work on water supply. They are more accurate, require less time and money, and have greater legal value in settling damage claims.—*W. Donaldson.*

Goiter Survey by Michigan Department of Health (Preliminary Report). Supplement to Michigan Public Health 12: 1, January, 1924. Bureau of Laboratories has conducted studies of the drinking waters in Michigan with reference to iodine content. Medical examinations of school children have been started. In county of Wexford rural prevalance of goiter in school children was 12 per cent higher than in city of Cadillac: rural water supplies contain no iodine; that of city, a very slight trace.—*E. S. Chase.*

Endemic Goiter as a Public Health Problem. O. P. Kimball, M.D. Michigan Public Health, 12: 2, 59, February, 1924. Account of the disease and of preventive measures against it. Refers to treatment of water supply; but author prefers, on ground of economy, individual methods of prevention by feeding iodostearine chocolate tablets to supply iodine deficiency.—*E. S. Chase.*

Hard Water and Water Softening. E. F. Badger. Michigan Public Health, 12: 3, 113, March, 1924. A general and popular article dealing with hard water, its effects, cost to public, origin of hardness, water softening, and its cost.—*E. S. Chase.*

Health Bulletin, State of Connecticut. 38: 2, 27, February, 1924. Typhoid fever death rate in Connecticut in 1923 was 2.6 per 100,000 population, compared with 3.0 in 1922.—*E. S. Chase.*

Report on the Public Water Supply of Delaware, Ohio. F. H. Waring. Public Health Reprint No. 776. Consisted of ground water, supplemented by use of Olentangy River, supplemental supply being used fairly regularly during 1920 and 1921. Disinfection of the river water failed to give uniformly satisfactory results. Outbreak of enteritis occurred in October and November, 1921. Typhoid death rate in Delaware averaged 32.1 per 100,000 for nine years prior to chlorination and 11.3 thereafter. Filtration of the supply was recommended.—*E. S. Chase.*

Will Combat Menace of Cross Connections. Anon. Weekly Bulletin California State Board of Health, 8: 15, 57, May 14, 1924. Regulations passed requiring permit of State Board of Health for cross connections. Water companies of municipalities are to be responsible to consumers for pollution of public supply through cross connections.—*E. S. Chase.*

Typhoid Caused by Breaks in Water and Sewer Lines. ANON. Weekly Bulletin California State Board of Health, 8: 15, 59, May 24, 1924. From April 27 to 30, 1924, reports of more than 200 cases of severe vomiting and diarrhea were received from that portion of South Pasadena supplied with water from two wells near a pumping station in Pasadena. Investigation revealed stoppage or back flow in main outfall sewer in vicinity of pumping station. Samples of water showed gross pollution. Pumping plant was shut down and water in reservoir chlorinated. Further investigations showed that low pressure steel pipe from two wells to pumping station passed directly over lateral sewer in street and that near this crossing the steel pipe was badly corroded with sewer gas, containing about a dozen holes $\frac{1}{4}$ in. in diameter. Sewer was found to be cracked, and, with surcharged sewer and corroded water pipe, opportunity for pollution of supply was ample. Two cases of paratyphoid and 17 cases of typhoid were reported in South Pasadena up to May 19.—*E. S. Chase.*

The Drought of 1923. ANON. Health Bulletin of the State of Conn. 38: 3, 67, March, 1924. Comparison of rainfall in 1923 at certain Conn. cities with previous records. Drought was felt mainly in localities close to sea. Drier periods, however, have been experienced in the past.—*E. S. Chase.*

Swamp Drainage. E. H. LOTZ. Health Bulletin State of Conn., 38: 5, 129, May, 1924. Water collected in one of the reservoirs of Southington, Conn., water works was high in color, due to 15 acre swamp tributary to reservoir. A ditch was excavated completely around the swamp. The results obtained were satisfactory, as color was nearly eliminated and runoff was increased. Part of ditch was dug by hand, at cost of 35¢ per foot; but larger portion was excavated by blasting and cleared by hand, at total cost of about 21¢ per foot. —*E. S. Chase.*

Semi-Annual Report Division of Sanitary Engineering. Illinois State Department of Health. HARRY F. FERGUSON. Illinois Health News, 10: 3, 101, March, 1924. An outline of activities of Division during last six months of 1923. Refers to epidemic in Chicago during November as the first of waterborne typhoid fever in the State since that at the Chicago and Alton shops, Bloomington, in 1919. Epidemic at Chicago comprised a little less than 200 cases and 16 deaths. It was confined to an area with population of 450,000, supplied from 68th Street pumping station. At time of infection, lake water carried more than average pollution due to reversal of flow in sewage laden Calumet River and out flow of some sewage at 39th Street pumping station of the Sanitary District. Health Department recommended employment of sanitary engineer to give entire time to sanitary control of water supply.—*E. S. Chase.*

A Unique Method of Cleaning Filter Sand. C. H. CAPEN. N. J. Public Health News, 9: 6, 190, May, 1924. Rapid sand filters at Salem, N. J., became badly clogged with accumulations of fine mud. Ordinary washing failed to clean filters and chemical treatment was resorted to. One hundred seventy-five pounds of caustic soda and 250–300 pounds of soda ash were applied in solution to each filter (190 sq. ft.) from the top and heated to about 175°F. by

steam. This temperature was maintained in the filter bed for 40 hours in one case, and 80 hours in another. The filters were then washed several times. Stratified mud layers accumulated on sand surface and were removed by hand. Marked improvement in condition of filters was effected.—*E. S. Chase.*

Typhoid Epidemic in Ramsay, Michigan. C. H. Benning, M.D. Michigan Public Health, 12: 4, 149, April 1924. Account of an outbreak of some 35 cases of typhoid in mining town of 1800 inhabitants in Upper Michigan. Outbreak was confined to section of town supplied with unpurified river water. Inhabitants had been warned not to use this supply for drinking purposes; but warning was unheeded. Emphasizes danger of accessible polluted supply, and fallacy of belief that warning against use of such water will be heeded.—*E. S. Chase.*

Division of Sanitation. (N. Y.) N. Y. State Dept. of Health Quarterly, 1: 1, 30, April 30, 1924. Brief summary of acivity of Division in 1923. Refers to fact that drought of that year resulted in serious shortage of water in various municipalities, with consequent use of emergency supplies from polluted sources. Emergency chlorine apparatus were installed, in some cases by the municipality, and in others, by the Division. One municipality experienced a serious outbreak of intestinal diseases due to pumping of polluted water into mains.—*E. S. Chase.*

Report of Division of Sanitary Engineering. (Va). Richard Messer. Virginia Health Bulletin, 16: extra No. 6, April, 1924. Reprint biennial report of State Board of Health for 1921–1923. Reviews activities of Division and gives much detailed information regarding water supplies of Virginia. Refers to fact that only one small water borne outbreak of typhoid occurred in Virginia in three successive years. Describes an interesting experience at Charlottesville, with purification plant consisting of slow sand filters, filtered water aerator, and chlorination. Plant was installed in 1922 to remove algae, odors, and color. Satisfactory results were obtained for about 1 month; when color of filtered water became higher than that of raw. Trouble due to iron, which originated in reservoir in organic combination and was deposited in filters in zone devoid of oxygen and rich in carbon dioxide. This resulted in solution of iron and saturation of the sand bed therewith, to be followed by unloading of accumulated iron. Scraping and aeration of beds were found to be a temporary remedy only. As result of investigation, spray nozzles for aeration of raw water prior to filtration have been installed.—*E. S. Chase.*

The Determination of Manganese in Water. W. D. Collins and Margaret D. Foster. Ind. Eng. Chem., 16: 6, 586, June, 1924. Use 100 cc. of water, or such portion as will contain less than 0.1 mg. of manganese. Add 10 cc. dilute nitric acid (1 part strong acid to 3 of water), 1 cc. concentrated sulfuric acid, and heat in beaker on hot plate to drive off most of sulfuric acid. Cool, take up with about 50 cc. water and 20 cc. dilute nitric acid through which air has been bubbled to remove oxides of nitrogen. Add 0.10 gm. sodium bismuthate, stir for 1 or 2 minutes, allow excess bismuthate to settle, and

filter through alundum, or through Gooch crucible with mat of ignited asbestos, treated (by filtration) with permanganate solution and then washed. Dilute filtrate to definite volume and compare with standards prepared from appropriate volumes of standard permanganate solutions, containing the same quantity of nitric acid, as used for the sample, and adjusted to same volume. The reasons for the various modifications are explained in the discussion.—*Linn H. Enslow.*

Chemical Exchange Reactions of Zeolite. C. J. FRANKFORTER AND FRED W. JENSEN. Ind. & Eng. Chem., 16: 6, 621, June, 1924. Replacement of sodium of zeolites by other metals such as barium, calcium and magnesium, is strictly stoichiometric. This is regarded as evidence that the reaction is not due to absorption phenomena. Base exchange in highly dilute solutions, such as natural waters, is more nearly complete than at greater concentration, thus indicating ionic reactions. Barium showed approximately four and one-half times the replacing power of calcium when both were present in chemically equivalent amounts. The variation in composition of the zeolites studied renders any definite statements as to their exact chemical constitutions impossible. The general formula given by manufacturers was $2\ SiO_2 : Al_2O_3 : Na_2O : 6H_2O$.—*Linn H. Enslow.*

Bleaching Powder Explosions. AUGUSTUS H. GILL. Ind. & Eng. Chem., 16: 6, 577, June, 1924. Investigation of cause of explosion of cans and drums of bleaching powder has revealed following facts. Oxygen evolution by decomposition of $CaCl_2O_2$ produced in some cans pressures up to 13.6 pounds per square inch, corresponding to not more than 0.7 per cent of contents of can. Oxide of iron if present acts as a catalytic agent, increasing the rapidity of gas formation. Oxide of manganese plays a similar role, but to a lesser degree; on the other hand, a mixture of the two oxides is more powerful than either alone. Calcium chlorate, which is always found to some extent in bleaching powder, also increases and prolongs oxygen evolution. Analyses of various samples of bleaching powder which had caused explosions showed presence of manganic, as well as of ferric oxide.—*Linn H. Enslow.*

Electric Motors for Driving Centrifugal Water Pumps. ERIK G. SOHLBERG. Chem. & Met. Eng., 30: 21, 832–3, May 26, 1924. Large users of pumped water generally find it more economical to install motor-driven centrifugal pumps, purchasing power from some local electric service corporation. Reasons are; lower first cost, lower fixed charges, lower cost of maintenance, lower cost of operation, and higher efficiencies in case of large central station. When everything taken into consideration, motor-driven centrifugal pumps will operate at about 76 per cent of cost of reciprocating engines and plunger pumps with boiler plant.—*John R. Baylis.*

Why Caustic Solutions Make Steel Brittle. R. S. WILLIAMS AND V. O. HOMERBERG. Chem. & Met. Eng. 30: 15, 589–91, April 14, 1924. Continued use of waters containing sodium bicarbonate often leads to intercrystalline cracks in riveted joint areas. Mild steel is made distinctly brittle, under

influence of cathodic hydrogen. In the investigation, an external electromotive force was used to increase quantity of cathodic hydrogen. Four per cent caustic soda was placed in contact with one side of a test bar and distilled water with the other. Both solutions were protected from the air. Gaseous hydrogen that penetrated through the $\frac{1}{8}$-in. specimen into the distilled water was collected and measured. The difference in rate of penetration when in strained, and when in unstrained, condition was quite marked. Slag in mild steel was acted upon rapidly. Conclusions:—During crystallization of steel, the impurities, to a considerable extent, are rejected to grain boundaries. Oxides and sulfides are two of prime factors in caustic embrittlement: oxides are reduced under influence of cathodic hydrogen; sulfides are removed by caustic soda, thereby rendering conditions favorable for progressive corrosion. Hydrogen conduces in three ways thereto; (1) by the temporary embrittling effect of absorbed hydrogen; (2) by oxide reduction; and (3) by effecting changes in volume at grain boundaries.—*John R. Baylis.*

NEW BOOKS

Cours de Distributions d'Eau et des Egouts. LEVY-SALVADOR AND CAUVIN. 4 vo, 17 x 22 cm., 464 pages, 304 fig., 16 plates, without text, Libraire de l'Enseignment technique, Léon Eyrolles, editeur, Paris, 30 francs.—*Jack J. Hinman. Jr.* (*Courtesy Chem. Abst.*)

Precis de Chimie Physique. H. VIGNBRON. 8vo., 420 pages, 117 figs., Masson et Cie, Paris, 30 francs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*

Theorie de la Combustion et Utilization des Combustibles. LÉON LESUR. Vol. II, 16mo., 250 pages, 31 figs., Gaston Doin, editeur, Paris, 10 francs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Analysis of Potable Waters. P. MOLLIEX. (Preface by DIENERT). 96 pages. Librairie le Francais, 91 Bvd. St. Germain, Paris, 4 francs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

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METHODS OF MAKING FLOW TESTS AND THEIR VALUE TO WATER WORKS ENGINEERS[1]

BY GEORGE W. BOOTH[2]

About twenty years ago, the National Board of Fire Underwriters organized a corps of engineers to survey and report on the adequacy of the fire fighting facilities of the larger American cities; since that time other fire insurance organizations have undertaken similar work for the smaller towns and villages and have extended its scope to cover individual plants or risks.

It was early emphasized that pressure alone meant nothing with respect to the delivering capacity of a water system, and various attempts were made to devise a practical method of measuring fire flow available. Calculations could be made in some cases, but these became much involved in a well gridironed system, and were misleading in many instances. In some of the early tests of systems, a number of engines were connected to hydrants and operated simultaneously; this was expensive and inconvenient, and left the city poorly protected during that time. Other methods were used, such as the flow from a number of hydrants through short hose lines or the discharge of individual hydrants through a special venturi nozzle. Eventually a system of testing by groups of hydrants was evolved, and after

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

[2] Chief Engineer, The National Board of Fire Underwriters, New York, N. Y.

various modifications as to methods, a scheme as outlined herein was worked out.

The equipment necessary consists of a hydrant cap tapped to take a pressure gage, four Pitot blades, four 50-pound gages, and one 100- or 200-pound gage, depending upon the static pressure on the systems.

The Pitot tube used in determining discharges from hydrant outlets has a straight blade about 4-inches long, which is threaded to permit connecting to a piece of $\frac{1}{4}$-inch brass pipe 8 or 10-inches long, on the other end of which is screwed the gage by which the velocity pressure of discharge is determined; a union may be used to keep the joints tight in whatever position the gage may be.

The gage best suited for the Pitot is a 3-inch, graduated in half pounds, from 0 to 50 pounds. Such a gage may be read easily to the nearest quarter pound; corrections should be made as indicated by calibrations before and after using, either by means of a weight tester, or by comparison with an accurate test gage.

The method of conducting the tests as practised by engineers of the National Board of Fire Underwriters is a development of the scheme of measuring discharges from smooth-bore fire department nozzles by means of a pitot tube and pressure gage, in the manner described by John R. Freeman in his "Experiments Relating to Hydraulics of Fire Streams."

It is possible to measure hydrant discharges with considerable accuracy by use of short lines of hose and large nozzles; however, in cities where the normal hydrant pressures are low, only a small part of the total quantity available for engine supply may be obtained in this way, and much more time and labor is consumed than when open butt discharges are measured. For these reasons, and in order that a representative number of tests might be made in a reasonable time in the various cities reported on by the National Board, the present scheme of measuring discharges from the open butts was worked out. It is believed that the results obtained will show not more than 5 per cent of error.

In measuring discharges directly from open butts, the orifice is often not completely filled, especially in the case of steamer outlets (4 or $4\frac{1}{2}$-inch) and the velocity of discharge is not uniform throughout the part that is filled; neither of these features is so marked in the $2\frac{1}{2}$-inch outlets and can usually be ignored in small outlets. The area of no flow is almost always a segment in the bottom of the

Fig. 1

outlet, of varying height, depending upon the design of the hydrant and somewhat upon the velocity of the stream. Any projection into the waterway such as the end of the stem of an independent valve, or a roughness of the nipple, will also produce small areas of no flow. The area of no flow is in most cases fairly well defined, and the shape of the "hole" is sufficiently uniform to enable its proportion to

TABLE 1

Discharge through circular outlets in gallons per minute for indicated velocity pressure in pounds

$$G = 29.83cd^2\sqrt{p}$$
$$C = 0.90$$

PRESSURE	DIAMETER OF OUTLET							
	$2\frac{1}{4}$ inches	$2\frac{5}{16}$ inches	$2\frac{3}{8}$ inches	$2\frac{7}{16}$ inches	$2\frac{1}{2}$ inches	$2\frac{9}{16}$ inches	$2\frac{5}{8}$ inches	$2\frac{11}{16}$ inches
pounds	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*
$\frac{1}{2}$	90	100	110	110	120	120	130	140
1	140	140	150	160	170	180	180	190
$1\frac{1}{2}$	170	180	190	200	210	220	230	240
2	190	200	210	230	240	250	260	270
$2\frac{1}{2}$	220	230	240	250	270	280	290	310
3	240	250	260	280	290	310	320	340
$3\frac{1}{2}$	250	270	280	300	310	330	350	360
4	270	290	300	320	340	350	370	390
$4\frac{1}{2}$	290	300	320	340	360	370	390	410
5	300	320	340	360	380	390	410	430
$5\frac{1}{2}$	320	340	350	370	390	410	430	450
6	330	350	370	390	410	430	450	470
$6\frac{1}{2}$	350	370	390	410	430	450	470	490
7	360	380	400	420	440	470	490	510
$7\frac{1}{2}$	370	390	410	440	460	480	510	530
8	380	410	430	450	480	500	520	550
$8\frac{1}{2}$	400	420	440	460	490	510	540	560
9	410	430	450	480	500	530	550	580
$9\frac{1}{2}$	420	440	470	490	520	540	570	600
10	430	450	480	500	530	560	580	610

the total area to be determined by measuring its height with a rule; for example, with a $4\frac{1}{2}$-inch outlet, an area of no flow 1-inch high forms 10 to 12 per cent of the area of the outlet, a $1\frac{1}{2}$-inch hole, 20 to 25 per cent and so on. In some cases pressure will not be sufficient to fill the nipple at the top. In such cases measurement of the depth of water flowing will suffice to determine the discharge.

In determining the average velocity of the stream issuing from the outlet, the Pitot tube is moved throughout the area, and the observer will soon train himself by this traverse to fix upon a substantially accurate average; readings noted at the center and near the ends of the horizontal and vertical diameters will usually suffice, and the center reading in a small outlet is in most cases very near the average for the entire area. Readings should not be taken closer than $\frac{1}{4}$-inch to the sides of the orifice, since there is a noticeable retardation of velocity caused by friction against the walls of the hydrant nipple. This retardation necessitates applying a coefficient of discharge, which has been determined by experiment on three different makes of hydrants with outlets of various sizes and with velocities of discharge ranging from $1\frac{1}{2}$ to 28 pounds; the discharges as measured by the Pitot tube were compared with those determined variously by Venturi meter, Pitometer and Worthington current meter. The coefficient of discharge ranged from 0.85 to 0.96 with an average of 0.91. It is therefore concluded that a coefficient of 0.90 is a fair one to use; this is applied after allowance had been made, as heretofore mentioned, in the case of outlets not completely filled by the stream.

Velocity heads of 1 pound or more are desirable since they are read with greater accuracy by the ordinary observer, and also because any inaccuracy in the gage reading has less effect on the correctness of the discharge figures. However, discharges may be determined with considerable accuracy in cases where the velocity head is as low as $\frac{1}{4}$ pound. It is better where discharges are small to use only one small outlet, rather than two small ones or a large one.

The number of hydrants in a group, the discharges from which are read simultaneously, is usually four. In exceptional cases more hydrants are opened, depending upon the quantity of water available, the pressures and the character of the district in which the test is made. It is usual to open one steamer or two hose outlets on the hydrants used. It is better not to open enough outlets to lower the pressure in the mains to a figure below that assumed to be the minimum consistent with good fire service, which will be 20 pounds where pumpers are used, or 60 to 75 pounds or more where pressures are high enough to furnish effective streams direct from hydrants. Generally if sufficient water is drawn to lower the pressure in the mains 10 to 15 pounds the test will be satisfactory. Diameters of outlets are recorded to the nearest sixteenth of an inch.

The pressure in the mains before and during the tests is determined by attaching a gage to a hydrant preferably located near the center of the group to be tested; it is sometimes advisable to have another gage at a hydrant outside the group, to determine the loss of head in the main arteries, or a recording gage located near the center of the distribution system may serve the purpose for a number of groups. Knowing the loss of head due to ordinary consumption, and the additional loss due to the measured flow from hydrants, a close approximation may be made of the quantity available at any given pressure. Care should be taken in the selection of the location of the residual hydrant, as the accuracy of the test will be affected by the location. The ideal test consists of opening a hydrant each way from the residual.

With a known drop in pressure when a known quantity of water is drawn, it is comparatively easy, by using a hydraulic slide rule, to estimate the quantity of water available at any residual pressure. This method can be used in connection with most tests, but can not be used where the assumed residual pressure would lower the hydraulic gradient below the high point of any main between the supply works and the test.

In making flow tests and in studying the results, actual conditions at time of serious fire should be taken into consideration. For that reason, tests in a system which has a small standpipe near the point of test give an erroneous result, as the main flow for the few minutes after the hydrants are open will come from the standpipe. In cases of this kind, it is best to run the test with the standpipe cut off.

Fire protection engineers making reports upon the adequacy and reliability of water systems find that flow tests are undoubtedly the most practical, economical and instructive method of studying the efficiency of a distribution system. Similar tests could be profitably used by water works engineers in designing reinforcements to a distribution system and in keeping informed of the condition of an existing system.

A carefully designed distribution system may in the course of time prove inadequate, unless the community develops in such a way that its requirements do not exceed those assumed when the system was originally designed. If the character of the community changes, the existing system may become deficient. Although the system may appear to be as efficient as when it was first installed, yet the limit, beyond which the inadequacy will soon be evident, may have

been reached. For example, in the City of Paterson, N. J., a district which was originally residential in character gradually became a factory section, but without a proper strengthening of the distribution system; in the conflagration which swept part of the city, this condition was forcibly brought out, as a number of the factories though well equipped with fire pumps, could not be saved as there was a serious shortage of water.

In order to learn the exact condition of a distribution system an investigation of the actual capacity throughout its extent should be made. Such an investigation is best made by means of flow tests and the results obtained often indicate ways in which the operation of the system can be improved. An interesting example of this occurred several years ago in Buffalo. The city is supplied in two zones, and originally the congested value district, in which are millions of dollars of value in buildings and contents, was supplied from the low pressure zone. To improve pressure, and thus make the water supply better available in the higher buildings, the zone limits were changed by opening certain valves and closing others, thus throwing some of the mains in this district into the high pressure zone. Pressures were increased, and it was believed that the desired results had been accomplished. A flow test, however, showed that, despite the increased pressure, the change resulted in only 3,300 gallons a minute being available in the heart of this district; the estimated required flow was 12,000 gallons a minute. Investigation showed that with slight changes as to closed valves and the transfer of one large main from the low service to the high, material improvement would result. These changes were carried out, after which a flow test was made, with the result that a supply of 18,000 gallons a minute was obtained, and with a considerably less pressure at the pumping station than previously.

In various other ways these tests are useful to a water works engineer. They show the effects of a known draft, which furnishes data to calculate the effect of any demand. They indicate the condition of the system with respect to obstructions, such as closed valves, acute bends, and sediment. They show the reserve capacity to meet the demands of a serious fire, results of broken feeder main, etc. They furnish data concerning the probable need of supporting mains and additional gridironing.

In general, two series of tests should be run, one on the arteries to determine their general adequacy, and the other on the minor

distributors to study local losses, including that in hydrants and hydrant branches. Where the desired flow for the district cannot be obtained on the arteries at a residual pressure considerably above 20 pounds it is obvious that at some distance from this large main the local losses will be such that the fire department will not obtain the required supply for fire engines.

In a number of instances artificial conditions have been created similar to those which would exist during some emergency operation, and tests have been run to indicate the protection then available. Several years ago, the question arose in New Orleans as to the probable result on fire protection if a 48-inch artery was broken; this condition was assumed and a series of tests run with one section of this line closed off. The results of the tests were conclusive and more convincing than any amount of calculation.

In one of our investigations, flow tests taken in the day time gave fair to good quantities of water in the mercantile district, but the fire chief was not satisfied as he had recently experienced a shortage at a night fire. A test was run at midnight, with about the same flow for about one minute after the hydrants were open, but it was noted that the residual pressure gage was still going down and continued to do so for a period of half an hour when it became stationary at 20 pounds, with a total flow from the hydrants of less than 500 gallons. The explanation was that each night the gate valve on a reservoir outlet was nearly closed, "to prevent heavy wastage in case of a break in the system during the night." The high flow on the first reading came from the storage in the pipe system on the hills; among other things this test indicates the need of keeping hydrants flowing until the residual becomes stable.

Another interesting test was on a system of a private company. We were told the system was all in one service or zone from a reservoir. Tests at various places showed very erratic results; much greater flows from one hydrant than another and either very little drop or very great drop in the residual pressure, none of which could be accounted for by size and locations of mains. When the matter was taken up with the superintendent as to the probability of closed gate valves he proudly explained his method of operation, which was to isolate various sections of the city by closing all gate valves except on one line, thus permitting him "in case of a break to shut off the district by operating only one valve."

For a number of years the water department of Brooklyn, N. Y., maintained a party which conducted flow tests whenever there was any question of adequacy of supply, and it was on the basis of the results obtained that reinforcing mains were installed. These tests were largely in manufacturing sections, where it was a question of adequacy of supply to automatic sprinklers and other fire protection equipment.

It is now a recognized practice of insurance inspection organizations, where an automatic sprinkler system receives its supply from city mains, to conduct a flow test at the nearest hydrant to the plant, and, from this, determine if the system can deliver at least 500 gallons for the smaller plants and 1,000 gallons for the larger ones, while maintaining a pressure in the mains sufficient to serve the top line of sprinklers. The Brooklyn investigation went even further, inasmuch as the flow was not considered satisfactory unless 5,000 to 10,000 gallons a minute were available at a pressure of at least 20 pounds. The ultimate result of these tests was that numerous 12-, 16- and 24-inch lines were laid through a section of distribution which previously was largely 6-inch.

Detroit recently completed tests embracing its entire system and the data obtained were used as a basis in determining the reinforcement necessary in those sections where the supply was deficient. Upon the completion of the reinforcement, tests were again made in the sections strengthened, to determine the effect of the improvement.

Baltimore pursued the same policy in the Highlandtown-Canton districts and Milwaukee is considering a similar investigation.

Chicago in 1913 made a detailed study of a section, three square miles in area, using flow tests to determine the available supply. The investigation resulted in the replacement of a mile of 4-inch pipe by larger sizes, the laying of 2½ miles of 6-, 8- and 12-inch pipe for the purpose of eliminating 18 dead ends and furnishing better supply to 28 small mains. Seventy-six small hydrants were replaced by larger hydrants, and 39 new hydrants were installed. This improvement, for which $50,000 was appropriated, resulted in increasing the supply 225 per cent.

Following are a few of the many examples of observations in mains discovered by our engineers after making flow tests.

In an Ohio city of 30,000 population, flow tests indicated that the system was not delivering its full capacity. On subsequent inves-

tigation, a closed valve was located on a 20-inch supply line which, when opened, increased the supply 290 per cent and pressures during domestic consumption 5 pounds.

In a Connecticut city of 100,000 population, a valve was found closed which, when opened, increased the flow 16 per cent and decreased the pumping head 12 pounds.

In a Michigan city of 50,000 population, where there are two mains in the main street of the principal mercantile district, flow tests showed good supply to hydrants off one main and poor supply to hydrants off the other. Subsequent investigation showed two closed valves in one of the mains and a closed valve in a cross-connection.

In a New Jersey city of 75,000 population, flow tests in one section showed 200 gallons a minute with a residual pressure of 0. After two valves, which were found closed, were opened and a cross-connection was made to a feeder, a test at the same location gave 2,080 gallons a minute, with a residual of 19 pounds.

In a Pennsylvania city of 65,000 population, a 30-inch valve on a supply line was found throttled; in a New Jersey city of 140,000 population, 6 valves were found closed; in a Rhode Island city of 60,000 population, a 20-inch valve was found closed; in a Virginia city of 150,000 population, a 16-inch valve was found closed; in a Kansas city of 50,000 population, four 12-inch valves were found closed.

These examples illustrate the advantage to operating engineers of making periodic tests at certain locations to determine whether the system is delivering its full capacity.

A thorough study of flow tests in connection with pressure observations along the feeder mains will often give interesting data on consumption and aid in waste investigation. A very decided drop in pressure on a gage located on the supply main, particularly when the flow drawn is small, is indicative either of an obstructed line or a line delivering nearly its full capacity. Such a study made of tests in a city in central New York indicated that the normal consumption was exceedingly high; as there was no meter on the line, further investigation was made of pressure at night and during the day, and at time of flow test, with gages at several points on the supply main, with the result that it was determined consumption was at a rate of over 500 gallons per capita. Subsequent waste investiga-

tion confirmed this and sufficient waste was eliminated to defer expensive further development of the water shed and an additional supply main.

One of the greatest practical benefits to be obtained from flow tests is in the object lesson furnished to the city council or other body that hold the appropriating power. A weak test near the home of a councilman, or about the factory of an influential citizen will often open the purse strings. A few years ago, a series of tests were run in a New Jersey community, where, because of very high pressures, it was believed by all concerned the supply was generally ample, as the fire department had never complained of shortage. Tests in an old section of the system, where mains were 4-inch and 6-inch, well gridironed, soon showed the inadequacy of the supply for a serious fire; the evidence was so convincing that an immediate appropriation for over 12 miles of mains was made.

THE RELATION OF FIRE PROTECTION REQUIREMENTS TO THE DISTRIBUTION SYSTEM OF SMALL TOWNS[1]

By Clarence Goldsmith[2]

In the design of the pipe distribution system of water works to supply a small town, the selection of the pipe sizes should be based upon the fire protection requirements. The rates at which water must be furnished to supply even moderately adequate fire protection far exceed those which are required for domestic consumption and the few manufacturing activities. Consideration should be given, therefore, to determining the probable fire demand.

Sections containing small dwellings of low heights occupying not more than one-third of the block front require two fire streams, or not less than 500 gallons per minute. It is true that a large proportion of fires occurring are extinguished by chemicals, small appliances, and perhaps a dash of water from a single hose line, but provision should be made to cope with a fire which has reached considerable magnitude by the time the fire company arrives. Where the buildings are sufficiently close to expose one another, i. e., with a separation of 50 feet or less, such as occurs at and near the business center, a further complication occurs, for additional streams are needed to protect the exposed building or buildings. It may be assumed, therefore, that two additional streams or four in all should be provided for even the smallest community at places where buildings are grouped.

For effective fire fighting in order to prevent the fire from spreading from building to building where the buildings are congested, the streams should be of sufficient size to penetrate the burning building and wet down those buildings which are exposed. This requires playpipes having nozzles of $1\frac{1}{8}$ to $1\frac{1}{4}$ inches in diameter and fair pressures, for a nozzle pressure of from 30 to 40 pounds is required

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

[2] Assistant Chief Engineer, The National Board of Fire Underwriters, New York, N. Y.

to give an effective horizontal or vertical reach of about 60 feet It therefore appears reasonable that towns having populations of 2000 or less should have four or more fire streams of 250 to 300 gallons available, which makes a minimum requirement for fire protection of from 1000 to 1500 gallons a minute. More water is required for the protection of larger towns, and this subject has been thoroughly covered by previous papers presented to the Association.

The next step in the design of a distribution system is to provide for the concentration of the streams. The friction loss in fire hose is one of the greatest limiting features in fire fighting, and, together with the number of streams required, determines the location and spacing of the hydrants, for unless a sufficient number of hydrants are provided, the loss in the long hose lines renders an otherwise satisfactory supply ineffective. In order that there may be no unnecessary loss between the mains and the nozzle, the hydrants should be of such size and design that the losses in them are kept at the minimum. The hydrants should have a sufficient number of outlets to permit the connecting of the required number of hose lines. With the assumption that four fire streams are the minimum required for any group of buildings, it is evident that at least two hydrants should be available. Hose lines should not exceed 400 or 500 feet in length, which requires that the hydrants be not more than 300 or 400 feet from the buildings to be protected. Where direct hydrant hose streams are used, these distances should be about 100 feet less than when fire engines are available to raise the pressure. As a general proposition, there should be one hydrant at each street intersection, and intermediate hydrants should be set where the distance between street intersections exceeds 350 or 400 feet.

When the quantity of water required for fire fighting needs has been determined, a map should be prepared showing the streets; and buildings and groups of buildings to be protected should be indicated on the map. It then becomes a simple matter to place on the map the necessary hydrants to enable the number of streams required in the various parts of the town to be concentrated in a satisfactory manner. With this preliminary information available, the design of the distribution system can be approached in an intelligent manner.

Although it generally would not be economical in designing a a distribution system for a small town to provide for the protection of additional values, which would probably develop in the next

fifteen or twenty years, yet the design of a system should be made with this in view. It would not mean that the mains to be laid should be of sufficient capacity to care for these possible future demands, but the pipes now being laid should be so routed and of such capacity that while taking care of present requirements they would lend themselves to incorporation in a system which might be required twenty years hence.

The location of the source of the supply has a most important bearing on the design of the distribution system for the maximum fire demands necessarily tax any economically designed distribution system to its utmost, and, therefore, all mains laid should be located with the idea of making them available as water carriers to the points where the greatest fire demand will occur. This is usually in the center of a town, although frequently a group of manufacturing buildings or warehouses along the railroad in some other part of the town may require as much and sometimes more water than the mercantile center, although ordinarily this center is the determining factor in settling upon the capacity required. It is desirable to have the mains serving the central section enter from at least two sides in order to utilize their greatest capacity and, at the same time, secure reliability in case of accident. It is seen, therefore, that the most ideal layout is to have a pumping station on one side of the city and elevated storage on the other side, provided the topography is such that a sufficient elevation is available for a reservoir. Standpipe storage is seldom of any value in an extended fire, but such storage is often economic from the operating standpoint, as it permits the shutting down of the pumps in small plants during the night and also can furnish the fire demand for the short period required to get additional boilers, pumps, or other equipment into service in case of a large fire. It is always desirable to have the capacity of the elevated storage sufficient to equal or nearly equal the fire demand for a five-hour period.

When the location of the source of supply has been determined and it has been decided whether the fire supply could be best supplied from elevated storage, it is then necessary to determine whether dependence for fire fighting will be placed on the pressures carried in the mains or on fire engines. Effective fire streams require that pressures be maintained at the time of fire flow at about 60 pounds at the hydrant, although where buildings are low and scattered, this pressure may be reduced to 50 pounds. In order to maintain this

pressure for direct hydrant hose streams, the amount of pressure which can be lost by friction in the distribution system is necessarily very small. Where fire engines are used they can secure an adequate supply of water if the pressure at the hydrant is reduced to about 20 pounds, and in some cases where the mains are of ample size and low pressures are carried, due to low elevation of reservoir, pressures lower than this are capable of furnishing a satisfactory supply, but it is advisable to have 20 pounds available to overcome the friction loss in the hydrant branch, hydrant, and suction hose. In direct pumping systems it is practicable to carry fire pressure up to 100 pounds. When it has been determined what pressure is to be carried, either by the elevation of the reservoir or the elevation of the supply works, and the pressure to be carried at the pumping station, it is an easy matter to calculate the total permissible drop in pressure in the mains, due to friction, in order to furnish either 60 pounds or 20 pounds at any point in the system.

In order that the discussion may be confined as closely as possible to distribution systems, it will be assumed that the pumping station is located fairly close to the center of the town or that the supply main is of sufficient size to deliver ordinary consumption demands with only a few pounds drop in pressure. This is a reasonable assumption as the fire demands far exceed the consumption demand in smaller towns.

A study of the street map should now be made in order to select the most direct routes from the supply works to the point of greatest demand so that unnecessary friction losses will not be built up by following circuitous routes. At the same time consideration must be given to the protection of buildings between the pumping station and the center of the town. It is advisable to select certain streets through which additional mains may be laid in the future to meet the increased demands due to growth. After the locations of the through mains have been determined, the best method of connecting them and the best method of tying them together by mains of sufficient size to deliver the required capacity where it is needed should be considered. When this has been done, the next step is to provide mains to supply the other sections which it has been decided to serve. Mains extending into these sections should be looped, if possible, so that more adequate and reliable supply may be available from the hydrants than if they were supplied from dead ends, for friction losses are much less when equal quantities of water are being drawn from a looped line.

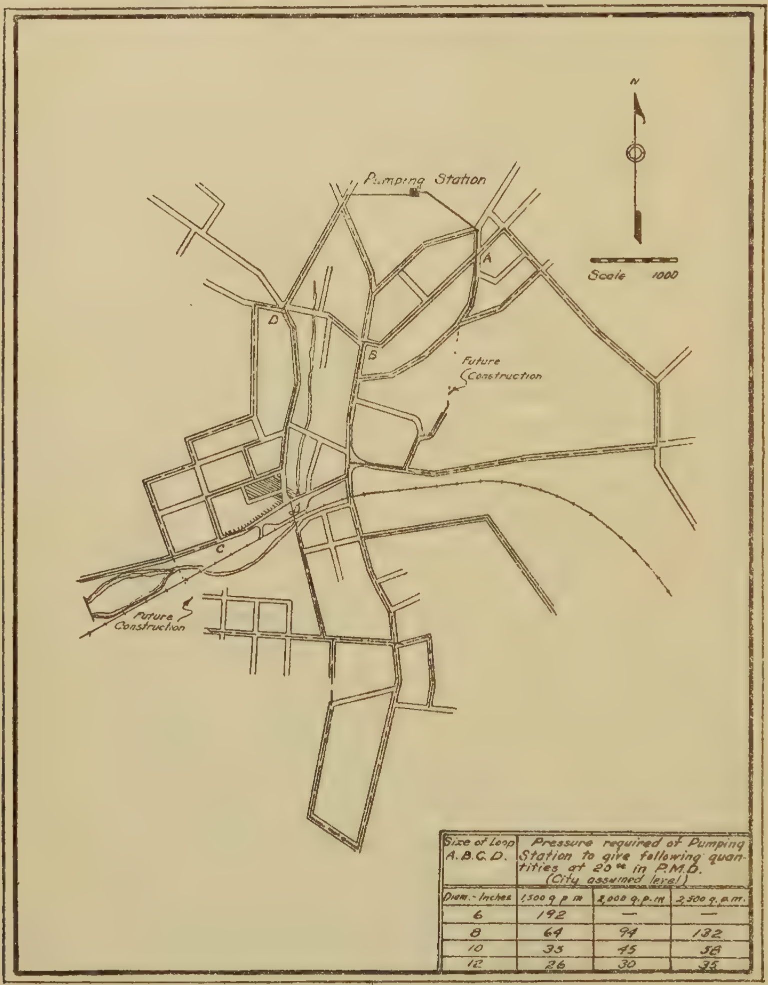
In making the preliminary design it will be found advisable to provide a fairly extensive system, and if estimates show that its cost will exceed the funds available, it will be possible to eliminate the immediate installation of mains in some of the streets by re-routing some of the lines and setting a second hydrant at some street intersections. When the growth of the city requires additional protection, in certain sections, the laying of mains in the streets originally left vacant will sufficiently reinforce the distribution system to meet the increased demands. In making this study, however, decreasing the sizes of mains for economic purposes should not be considered. It will probably be found necessary to furnish domestic consumption in some of the streets not served by the large mains which are originally installed, but this can be taken care of by laying service pipes of sufficient size to the premises of the consumer. One- and two-inch pipe will generally be found adequate for this service. By adopting this method it will be unnecessary to trench entirely through each street, and thus money can be saved. In the end this method is preferable to laying 4-inch mains, for they are not considered suitable for fire service. Friction loss in pipe of this size is 3 pounds per 100 feet for a flow of 250 gallons, and twelve pounds for 500 gallons. It is theoretically possibly to use short lines of 4-inch pipe for supplying one intermediate hydrant, but the actual saving in cost in using this small size pipe over using 6-inch pipe is not sufficient to justify its use, particularly as the capacities of modern fire engines range from 300 to 1000 gallons per minute, and average about 700 gallons. For the same resason it is undesirable to use 4-inch pipe for hydrant branches. Excellent fire protection in smaller places can be furnished by 6-inch pipe when looped or forming part of a gridiron system; however, when dead end lines exceed 800 feet in length, and it does not seem probable that they can be looped or connected for sometime, it is economical to use 8-inch pipe.

In laying out any distribution system the idea should not be lost sight of that it may be necessary to cut out any line at sometime in order to make repairs or connect into some extension. It is, therefore, essential in order to furnish reliable fire protection that two or more lines be laid in preference to a single line of equal carrying capacity. From pumping stations the mains should extend along two or more different routes and ultimately meet at or near the place of greatest demand. It is often desirable to lay mains cross-connect-

ing the principal feeders or force mains from the pumping station in order to provide local fire protection and domestic consumption, but it should be remembered that these mains do not contribute in any appreciable degree to the carrying capacity of the distribution system to the point of maximum demand, as their function is confined to furnishing the local supply or to give greater concentration at some intermediate point along one of the supply mains, i.e., if there are two mains from the pumping station to the mercantile district, a cross-connecting main at a half-way point will not carry any flow of water during a demand in the mercantile district, unless the size of one of the principal mains is changed at some intermediate point, in which case the cross-connecting main will come into play, and by equalizing the flow, enable more water to be delivered into the district considered.

When a system has once been installed, it is of prime importance that it be operated with all the valves open. This point is not only pertinent in a small town system, but assumes equal, if not greater importance, in larger distribution systems. In some larger cities it has been the custom to extend large mains for considerable distances through the distribution system without making any connections, or if they be made, operating with the valves on them closed. These mains are termed "trunk" or "express" mains, and are operated to deliver into remote areas under the impression thst this means a more satisfactory supply is assured. This is an erroneous assumption, for it is evident that if the distribution is so weak as to cause excessive losses under domestic consumption demand it will be entirely inadequate to furnish fire protection. When pressures in outlying sections are depleted to such a degree that the service is unsatisfactory, it should serve as a warning of the necessity of additional main carrying capacity, not only to deliver water into these outlying sections, but to increase the supply to the intermediate area. In a recent investigation the gates along a 16-inch line, which was originally connected to 6- and 8-inch minor distributors at street intersections, were found closed in order to make the large main serve as a trunk feeder into a district where pressures were depleted during periods of maximum consumption. Although the static pressure in the section served by this trunk line had been raised a few pounds, flow tests indicated that the fire protection available in the section had not been increased because at the time of fire draft dependence had to be placed on the 16-inch main and the carry-

ing capacity of the intermediate mains of the distribution system could not contribute to carry the fire flow on account of the closed valves. In the sections through which the main had been cut off

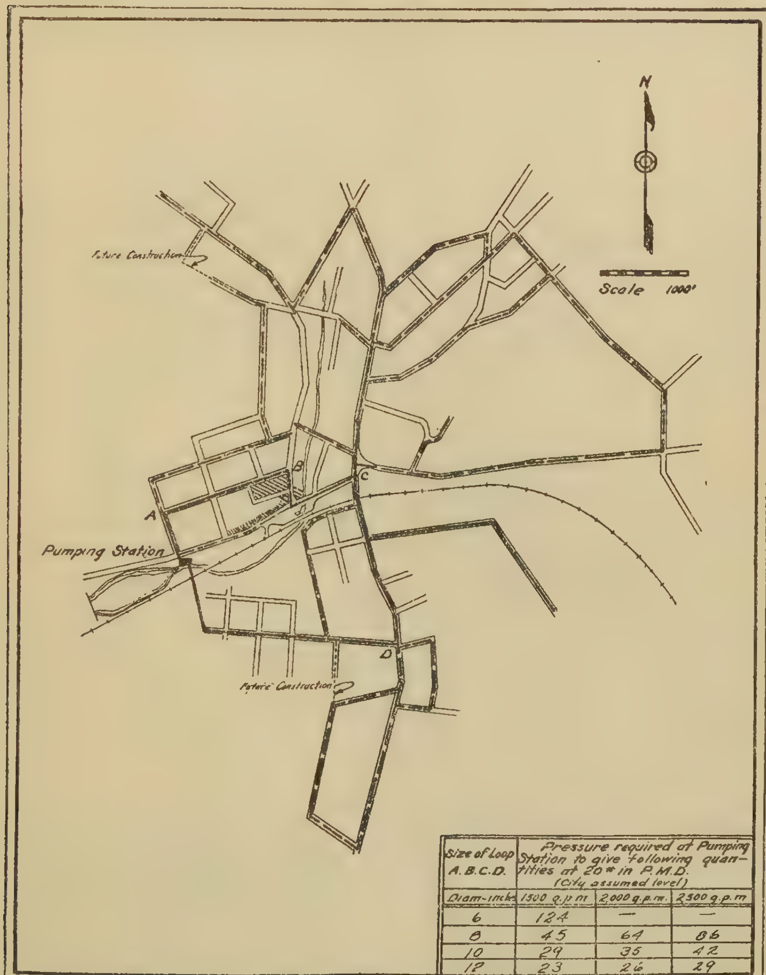


Size of Loop A. B. C. D.	Pressure required of Pumping Station to give following quantities at 20# in P.M.D. (City assumed level)		
Diam.-Inches	1,500 g.p.m.	2,000 g.p.m.	2,500 g.p.m.
6	192	—	—
8	64	94	132
10	33	45	58
12	26	30	35

FIG. 1

from the distribution system by closing the valves, the available quantities for fire protection had been reduced to less than one-fourth those previously available, and with four hydrants open none could deliver 500 gallons a minute.

In many systems it appears to have been the opinion of the engineers installing large mains leading from the pumping station that it was unnecessary to connect all of them to the intersecting mains

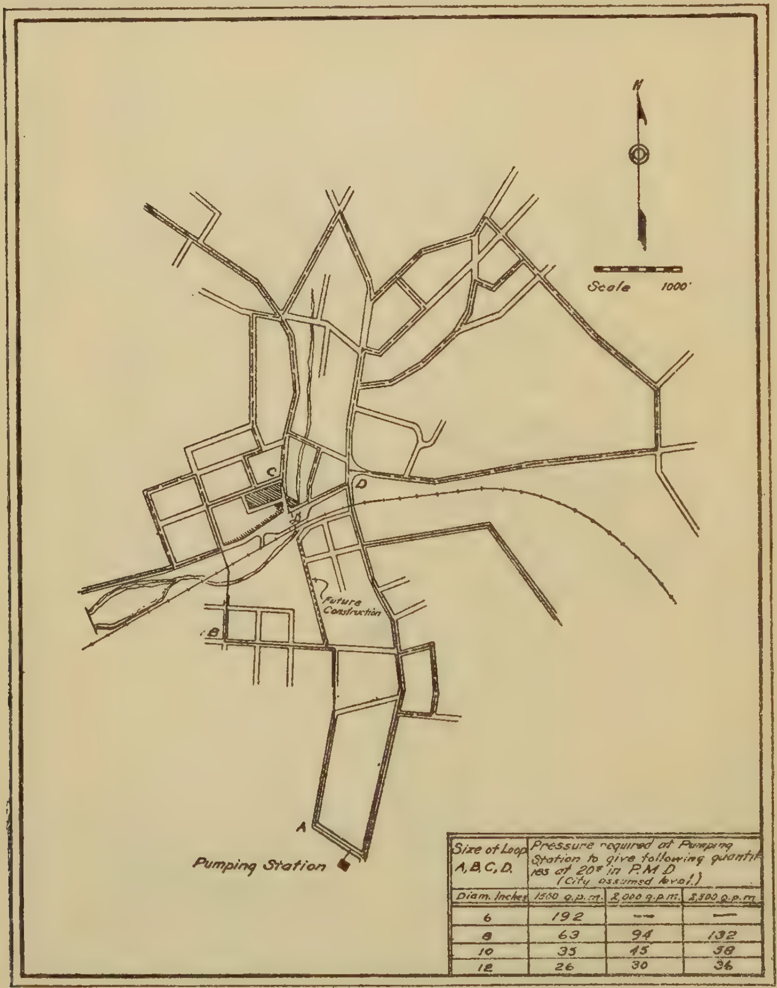


Size of Loop A.B.C.D.	Pressure required at Pumping Station to give following quantities at 20# in P.M.D. (City assumed level)		
Diam.-inches	1500 g.p.m	2,000 g.p.m.	2500 g.p.m
6	124	—	—
8	45	64	86
10	29	35	42
12	23	26	29

FIG. 2

of the distribution system. This may be true where these supply lines extend along the same or adjacent streets, but where they follow fairly well separated routes, it is obvious that these mains should be connected so as to feed the territory through which they

pass. Frequently the argument is advanced that the cost of the specials and additional gate valves necessary to make these connections is not warranted, and the reliability of these important lines

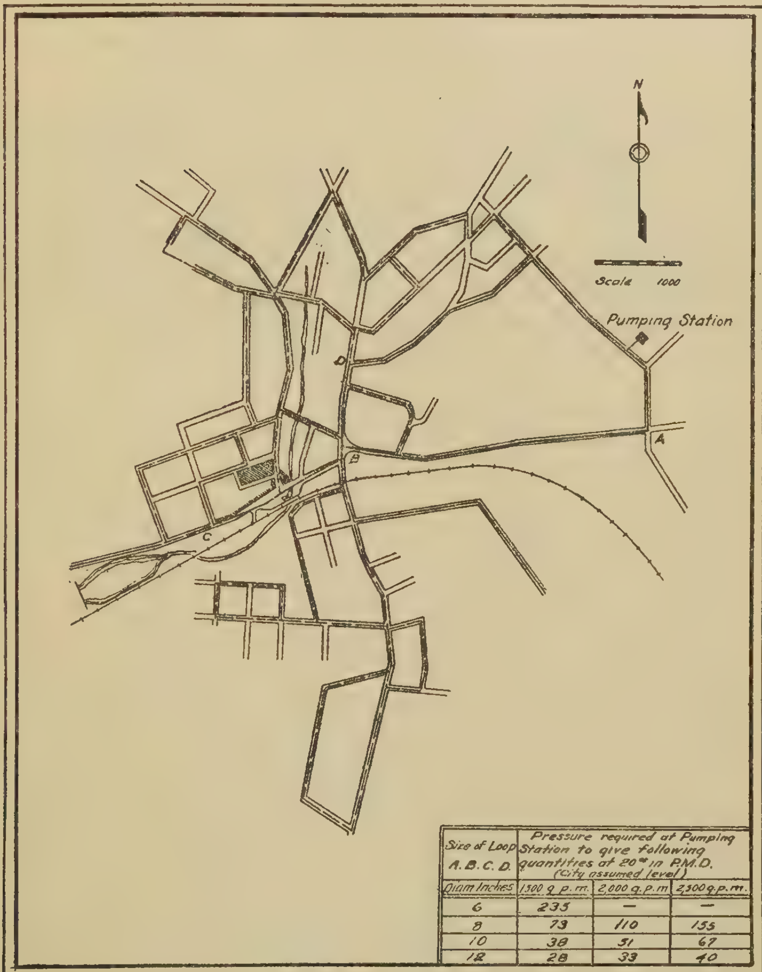


Size of Loop A, B, C, D.	Pressure required at Pumping Station to give following quantities at 20# in P.M.D (City assumed level.)		
Diam. Inches	1500 g.p.m.	2,000 g.p.m.	2,500 g.p.m.
6	192	—	—
8	63	94	132
10	35	45	58
12	26	30	36

FIG. 3

is menaced by the large number of connections. It is not necessary to connect each intersecting main with a large main, but all lines 8 inches and larger in diameter should be connected and those 6-inch mains which are not cross-connected within several blocks of

a large main. The best and most reliable method of connecting large mains with the minor distributors is by means of a run-around connection. These connections can be made between existing pipes by the use of tapping machines.



Size of Loop A.B.C.D.	Pressure required at Pumping Station to give following quantities at 20# in P.M.D. (City assumed level)		
Diam Inches	1500 g.p.m.	2,000 g.p.m	2,500 g.p.m.
6	235	—	—
8	73	110	155
10	38	51	67
12	28	33	40

FIG. 4

Four sketches have been prepared showing the possible design of distribution systems, with decidedly different street layouts, which will furnish adequate fire protection in towns having popula-

tions of from 1000 to 1500. The design and installations of water systems of this character are generally carried out by consulting engineers, and when they are completed, they are turned over to the town authorities for operation. Those to whom this responsibility has been entrusted should exercise the utmost care in so maintaining the system that it can operate at all times up to its designed capacity, and the officials of the fire department should always use the utmost discretion in determining the number of hose streams to be used, for if dependence is placed on direct hydrant hose streams and one or two streams in excess of the capacity of the system are used, the pressure at the hydrants may be sufficiently depleted so that all will be inefficient. If dependence is placed on pumpers, care should be taken not to endeavor to overtax any line so that the pumper nearest the fire will not be able to obtain a sufficient supply to develop the number of streams for which it is designed.

THE ECONOMIC SIGNIFICANCE OF FIRE WASTE[1]

By Franklin H. Wentworth[2]

I have not appeared before on the program or participated in the discussions of these meetings for I have felt that I had nothing to contribute on the subjects which have been under discussion. I feel very deeply, however, respecting the subject of this afternoon. In making the departure which has been indicated by your President and your President Elect, the American Water Works Association is entering upon a new field of its accountability. There is much that may be said respecting your relation as water works men, as water works officials, to the problem of fire prevention. I have been asked today to impress upon you another relation, the relation of you men as citizens to the fire waste of the country, which is now averaging $500,000,000 every year. Your President Elect has challenged my admiration in the last five years by his attitude as a citizen toward this most serious of American problems. Some philosopher has said that we are always surer that we see a star when we know another sees it; and when I encounter a man like Mr. Jordan, with his experience, his intelligence and his broad outlook upon life, and when he sees as clearly as I do the impoverishment of the country by this tremendous drain of $500,000,000 every year, 80 per cent of which is preventable by the use of ordinary care, then I am so much surer that I myself am not seeing ghosts in this matter.

The European fire waste averages about 33 cents per person; the American fire waste averages $5.00 per person. What is there in Americans as a people, what is there in our industrial, our social, our economic life, that contents us as reasonable human beings to contemplate year after year for decades such a shameful waste as this? It is partly due to our building operations of the past. Any people, any individuals, born to affluence and luxury will be easy spenders, and we Americans have been born and bred in the notion that our

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

[2] Secretary, National Fire Protection Association, Boston, Mass.

supply of natural resources was unlimited. Our supply of lumber did obviously once seem unlimited; when our fathers settled this New England coast, they had to cut down and burn beautiful standing pine in order to get at the soil to cultivate it, and that bred in them, and it has continued in us, the notion that our supply of lumber, at any rate, was inexhaustible; and so it has seemed easier and more natural for us to build and burn and build again than to adopt those methods of building long since adopted by the more prudent countries in Europe. Perhaps in the earlier days before the locations of our cities were permanently settled, there might have been something justifiable in the unstable building carried on in America, but now that our cities are located, now that the great avenues of commerce have been laid out and we know how our country is proceeding in its development, we have no longer an excuse for the shoddy building that has been so common among us.

But there is a more subtle point to consider in this discussion, and that is that this supply of building material, the unlimited resources in this country, has affected us psychologically. We do not realize that we have a mental attitude toward the fire waste that is wholly indefensible; that is an ignorant and stupid attitude. You will find men with all the marks of human intelligence reading a fire report. They glance down the column to see if the property is insured. If they find it is insured, they dismiss the matter from their minds as something that does not affect them. If the fire insurance companies received their revenues from Mars or Jupiter or some remote planet, we might afford to assume this indifferent attitude, but they have no way of getting their revenue except by assessing it right back upon you and me. It is perfectly obvious that they must collect enough to pay for this tremendous loss and that they must collect enough to keep their offices and agencies operating as going concerns. That is clear enough to the person who thinks at all about this question and yet the notion that is prevalent in America is that this fire waste does not affect us individually. What a pitifully ignorant point of view! The minute we look at the problem, as we look at other problems that affect our lives, we see at once that all these stocks of goods in New York, in Boston, in Philadelphia or in San Francisco are insured, the buildings which house them are insured, and that insurance is added to the cost of the goods, and when you buy a hat or a suit of clothes or a pair of shoes or anything which goes through the channel of production, distribution and exchange, we pay that fire tax, we pay

the cost of that tax merged with the cost of the goods, and in most of the things we use and consume there is a cumulative tax. Take cotton, for example. Cotton is insured in the sheds of the South; it is insured on the railway platform; it is insured in transportation; it is insured in the warehouse; it is insured in the textile mill or factory; it is insured in the department store or dry goods store; all the way along from the cotton field, that cotton bears a cumulative fire tax, and when we buy a bit of cotton goods we pay that tax merged with the cost of the goods. And so with leather, so with shoes. It is so with every commodity that is manufactured: the tax must be paid because the fire waste must be compensated for. Now it is that form of indirect taxation which puzzles the minds of our people and makes them so indifferent toward this problem. A $100,000 fire in Europe shocks Europe; all the continental newspapers comment upon it and want to know how it occurred, whether the conditions which gave rise to that fire could be duplicated in other cities. A $100,000 fire in Europe shocks Europe, but if we pick up a morning paper and do not find two or three $100,000 fires, or greater, recorded in it, we think it has been a dull evening. Now we must address ourselves to this problem and realize that it is the people themselves, it is you and I that are responsible for the careless habits which cause this most colossal waste.

Indirect taxation by which the fire waste is paid for is the most subtle kind of taxation. You remember what the French physiocrats, those great Frenchmen who tried to save the head of Louis XVI from the block when the people of France were eating grass in the parks, called indirect taxation: "The method of getting the most feathers with the least squawking." You can pluck people who do not understand the subtleties of taxation by indirect taxation; by putting the tax upon their food. They cry out against the high cost of living, the struggle to live, but they do not see the cause of it; they do not see how carefully the cost of living may be loaded by a system of taxation. That is why indirect taxation is "crooked taxation," it does not stay where it is put, it is passed on, it is shifted. If you pay an income tax or a real estate tax, you draw your check for it, you undergo the physical operation of being separated from your money, but a tax that merges with the cost of everything you eat, drink and wear you do not feel in its incidence. That is why the political scientists call it "crooked" taxation, that is why all tariff taxes are a form of manslaughter. Every indirect tax is evasive and

is unjustifiable because it confuses the minds of the people. Now, the problem is, how, are we to make our people conscious of this fire waste and its economic significance? Advertise a fire prevention meeting in the Manhattan Opera House here in New York for tomorrow night, and how many people would be in the audience? Half a dozen perhaps, no matter how much you advertised it. Fire prevention is too remote from the consciousness of our people. They think it is a fire insurance problem and leave it to the fire insurance companies, who are helpless against the effects of such ignorance. What can the fire insurance companies do except to collect enough to pay this loss? Our merchants must be compensated for fire losses; we want the insurance companies to be solvent, they must be solvent; we operate State Departments to see that they remain solvent, and to remain solvent they must collect enough to pay this stupendous loss of $500,000,000 a year and to carry on their business, else capital would flow out of fire insurance and we could not get the coverage our merchants need. I am not speaking for the underwriters; I am not an underwriter; the underwriters are capable men and can speak for themselves. I am merely showing you how the problem looks after studying it for awhile. How are we to reach the American people in their present state of mind? They are in a confusing backwash of the great war, careless, with all the old faiths crumbling, with nothing really to tie to. We are living in a jazz age, a motion picture age. In Boston, where I live, we used to have in our newspapers a pictorial supplement once a week; now we have them every day; our people cannot follow the news without pictures. It will be only by the grace of God if, in another generation, we do not forget how to read, even in Massachusetts! And we are obsessed by ideas of speed. What is the idea of youth today,—in a motor car? To get somewhere, where we are not, just as soon as possible; and when we get there, what? Come back again at 40 miles an hour! When we are confronted by a psychology like that; when we have a truth to force into the consciousness of our people and find this impossibility of fixing the attention upon any reflective subject. It is not an encouraging job for a man who wants his life to count for something. We used to think that all we had to do was to point out to the newspapers the profound economic significance of this problem, send out a few men to make speeches about it and the thing would solve itself, we Americans being the alert and careful and sensible people we are.

There are methods of legal persuasion and one of them is gaining headway in this country. If in France you should have had a fire and it got outside your premises and damaged your neighbor's property, you would have to pay your neighbor's loss. That is very educative. In some of the cities of Germany, the first person who calls to offer his condolence after you have a fire is the policeman, who locks you up, and you go before a jury next day and have to prove that there is no way in which you might have prevented that fire. If you cannot prove it, you have to bear the loss yourself and pay the city for the luxury of the unnecessary use of the fire department. That seems tremendously radical to the minds of our heedless citizens and yet do you know that idea is gaining ground in America? Pennsylvania a few years ago passed a State law that in cities of the second class, if a man disobeys a fire prevention order, he shall be liable in a suit by the city for the cost of extinguishing the fire. In certain cities of the West they have not waited for State laws. Cincinnati, Cleveland, Portland, Oregon, Austin, Texas, Newark. N. J., and a lot of cities scattered over the United States have embodied that idea in a local ordinance. In Cleveland if you get a clean-up order or an order for a fire door or anything of that sort from the fire department you will find on the back of the order a copy of this ordinance, and if you do not comply you are liable to the city in a suit; and even in the charter of the city of greater New York there is such a provision. How it got in there, no one knows, but when this charter of greater New York was drawn, someone wrote that provision into it; and there it lay all those years until Mayor Mitchell came in. Mayor Mitchell had a chief of his fire prevention bureau named Adamson, from Atlanta, Ga. Mr. Adamson did the unheard of thing for an American city official, he read the charter of the city he was going to serve, and he detected this provision in the charter. He watched the fires for a few weeks, and he found that a cemetery company down in lower Manhattan had a fire in a four or five story building full of caskets and excelsior and stuff that made a bad fire. It was expensive to extinguish and took lots of water; some of the firemen were hurt and some were overcome by smoke and were sent to the hospital, and it cost the city about \$2500 or \$3000 to extinguish that fire. Mr. Adamson found that about two years before the company had received an order to install automatic sprinklers in their building and he went to the company and showed them their liability. Did they offer to pay? No, they argued the matter. They said "Why should we pay for the

expense of extinguishing this fire? We did not set the fire; it was an act of God. We pay our taxes to support the New York Fire Department, why should we be assessed to pay for this fire?" The Commissioner said "Here is a provision of the charter, here is a copy of the order that was given by our department to you two years ago, and here are the results of the fire. You are clearly liable." They refused to admit their liability; the Commissioner brought suit, and the lower court, showing the psychology of our Americans, threw the case out. The Commissioner lost his suit, in spite of that clear evidence, through sympathy. We regard the man who has a fire,—no matter if his carelessness is responsible for it,—we regard that man with sympathy instead of accusing him from the European point of view as a public offender. But the commissioner was bound he would win his case if possible. So he took it to the Superior Court, and the Superior Court, being made up of superior men, as they sometimes are, reversed the decision of the lower court and gave the Commissioner damages. He compromised the suit for about $1500 and the cemetery company paid it. A week or two after that a film corporation had a fire; they found that they too had had an order six months before, and their manager went down to City Hall and said "How much is it, please?" I believe the amount was $750.

That is the individual liability point of view; we can force the individual to give attention to this matter by law, but it is so slow and the educational opportunities are so limited. Now we come to what you yourselves can do. What has Mr. Jorden done in Indianapolis? Each community has, or may have, the knowledge of how to prevent fires, how to extinguish fires, all the engineering knowledge from such men as Clarence Goldsmith and George Booth and others of that type. Having that knowledge, the question is how can it be applied? It can be applied by local committees; by cooperative efforts between the water companies and the fire chiefs and all the intelligent citizens of a town who see the terrible significance of this waste and are willing to do their share in its abatement. That is what is going on in Indianapolis, under an organization which Mr. Jordan as water works official and as Chairman of the Fire Prevention Committee of the Chamber of Commerce, with his circle of friends and acquaintances, has created. That is the work which I believe will be projected by the new fire prevention section of this Association; and it will be not wholly a public service, but a service to the water companies as well, because never is there a big fire that reservoirs may not be emptied,

that unnecessary drains may not be made upon the water companies, that new problems may not present themselves. While fire prevention presents problems with which the gentlemen of the American Water Works Association are intimately acquainted, yet out of a larger consideration of their significance may come wonderful possibilities of good citizenship, larger views of our responsibilities as citizens. It is a big job for big men to keep this country from a continued impoverishment which no country, no matter what its resources, can stand.

DISCUSSION OF FIRE PROTECTION REQUIREMENTS IN DISTRIBUTION SYSTEM DESIGN[1]

Mr. J. H. Howland:[2] As an engineer of the National Board of Fire Underwriters, it was my privilege and pleasure to work with Mr. Siems and his associates in making the studies of Highlandtown, Canton District, which I think I am safe in saying the great bulk of the matter in the paper[3] by Messrs. Siems and Biser was based upon. I think it is evident if one reads that paper and digests it, that in its preparation there was very careful study and a comprehensive knowledge of the subject. To me the paper has particular merit due to the fact that it points the way to a painstaking analysis of the varying conditions existing in different sections of our large cities. By the way, such an analysis is made in comparatively few cities in this country. I only know of those mentiened by Mr. Booth in his paper; Detroit, Chicago, Baltimore, and now I think Milwaukee is about to make such a study. Second, perhaps, in importance is the fact that it furnishes us with an excellent basis for a much more extensive study relative to the controlling factors in fire protection and fire extinguishment. It has been found true from years of experience that in most of our larger cities, at least, the size and general character of the congested value district, that is, the business and mercantile center, varies in fairly direct proportion with the population. The National Board of Fire Underwriters for many years has been using a formula giving the quantities required for reasonably good fire protection in which the population has been and is now the only variable factor; and I think that we are still to be convinced of the fact that the factors of area, height, combustibility, fire pump capacity and exposure hazards in the relative weights assigned to those factors in Mr. Siems' paper give any better results in the congested value districts of most

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

[2] National Board of Fire Underwriters, New York, N. Y.

[3] See Journal, January, 1924, page 17.

of our large cities than that very meagre formula which we have been using for so many years. I do not mean to say by that the factors which Messrs. Siems and Biser have introduced in this method are not more direct and have not more distinctly to do with this question of fire protection and prevention, because I think we must all concede that they do, but I do think, as I am going to show you in just a minute, there is some opportunity for further study and perhaps some modification of the relative weights given to those different factors.

Siems and Biser bring in as their first factor, that of area. Any fire chief of any generalship in our large cities will tell you that the fire area is the greatest factor in the control and extinguishment of fire. It sometimes occurs through unprotected vertical openings, and if fire spreads from floor to floor, that is the same thing, it involves an area built up on stilts rather than a horizontal area, and perhaps the former will spread more rapidly, but the area is unquestionably one of the biggest factors having to do with fire protection and fire extinguishment and I think any formula that is going to be used and generally accepted will ultimately embody this factor of areas.

They next bring in the factor of height, and as one of the previous speakers has said, when we get up above six stories, it is not a question of water and fire apparatus, we have got to handle it through house pumps and steps up into these higher buildings, so that up to six stories in height the effect upon fire departments and water supplies is very marked. In other words, you can control a fire in a one-story building much easier and with less water than you can in a six-story building, partly because of the unprotected vertical openings that I just mentioned, affording an opportunity for a fire to pass from the first story up into the second; it means larger areas and perhaps a harder matter to control. In other words, we recognize that these factors that have been embodied in the method suggested by Siems and Biser are worthy of very careful consideration and much more extensive study.

Now it was the endeavor of Siems and Biser to make this method applicable to great and small structures in both large and small cities; so we applied his method or selected at random nine widely scattered towns; three each of five, ten and fifteen thousand population, respectively, and the results obtained in applying their method showed that the required quantities for the smaller average areas in those congested or small mercantile, principally mercantile districts in

those smaller towns, compared very favorably indeed with the quantities required by our meager formula, in which population was the only variable factor. When we come into the larger areas, to take care of those exceptionally large buildings in those districts, we found that the Siems and Biser method resulted in very much greater quantities than in the average area. I might mention Riverside, California, as a special example. Those of you who have been there remember the Mission Inn. That is a very large fire area, about 9500 square feet. They also have a building known as the General Wood Garage, almost of equal area, right in the heart of that mercantile center. If you apply the Siems and Biser formula to those excessively large areas, you will find that for Riverside, a population of 20,000, we require them to provide 9500 to 10,000 gallons of water. I think you will all agree that it is hardly reasonable to expect a city of that size to provide any such quantity of water. If you take the average area of the buildings, the average fire area of the buildings in the Riverside mercantile district, you will arrive at about 12,000 square feet. There again the Siems and Biser method will require 6200 gallons, where our formula will require about 4200; so that in looking over all of these nine cities selected, it is very apparent that to make this method fit in with reasonable requirements, to the smaller cities particularly, it means that we have got to allow for area in particular, a less rate of increase than the average increase. I think that is one of the principal points I want to bring out. That justifies a great deal more extensive study and will undoubtedly result in a modification of their formula.

The second and third factors to which they refer, that is the allowances for excess fire pump capacity and for combustibility, are, in my opinion, as we have tried them out, closely approximate to what they should be. I do not think there will be any very great changes in those factors. I have come to the conclusion that the exposure factor should be modified whereby a proportionately smaller allowance will be made for the larger areas again. We find in application that the Siems and Biser formula affects the required fire flow for a thousand square feet in area, 2 per cent. If you apply it to a 15,000 square foot area, it affects it 30 per cent. Now just a suggestion, I have added one fire stream, 250 gallons, to his formula and given it as a larger denominator. It reads 250 plus Y square over 60,000, where the Siems and Biser was Y square over 50,000. You will find if you apply that to the different areas that it affects all the

quantities required for all those different areas about 25 to 27 per cent, a more uniform effect upon the different conditions. I might also say that I think their assumption that a building exposed on two sides is as bad as when exposed on four is logical and sound unless the wind is blowing in all directions, which certainly does not take place immediately. I do not know of any bad fires where I have seen a hard fight put up where they were fighting on more than two sides of a building involved.

Then the last matter I want to speak of is that we all recognize that the spacing of hydrants, which has been referred to by Mr. Goldsmith, certainly has to do with the ability to utilize the supply furnished or available from a distribution system. That has not been embodied in the formula suggested by Siems and Biser. I am inclined to think that any complete formula will embody that factor of hydrant distribution. Now in closing, I will say that I think perhaps the best guide to a further study of this paper is to go carefully into the past experiences which our organization has had quite an opportunity to follow up and keep in touch with, and after once determining the fair approximate quantities for reasonable fire protection, it becomes simply a matter of apportioning to the several factors, which admittedly are part of this fire protection and extinguishing problem, the proper relative values.

Mr. V. B. Siems:[4] The only thing I want to add is that we went into the industrial section of Baltimore and made very thorough surveys by the flow test and the like, and in no place could we find anywhere where the water consumption of such a big plant as the American Sugar Refining Company, for instance, exceeded the fire protection requirements. We did that over all the industrial territory, and we also did it in the other zones of the city.

Mr. Wm. Luscombe:[5] Mention was made in Mr. Booth's paper of the operation of gate valves. I understand it is a common occurrence for engineers, who are employed to make an investigation of waterworks properties to find gate valves in a distribution system closed that are supposed to be open and I believe those of us who are charged with the operation and management of waterworks utilities should certainly pay more attention to such matters and to make frequent,

[4] Water Engineer, Baltimore, Md.

[5] Vice-President, Gary Heat, Light and Water Co., Gary, Ind.

systematic and thorough inspections of all gate valves in the distribution system to make sure they are open as they should be. We may have pumps of ample capacity, oversized mains, and all that sort of thing, but all calculations of a city's fire fighting ability may be greatly upset and heavy damages unnecessarily result when, in the case of an extensive fire, the water pressure is seriously impaired because a gate valve was unintentionally left closed. I believe a special loose leaf book, or card index, containing a record of individual important valves would be of much value, showing their location, dates tested, condition found, inspector's name, etc.

RELATIVE ECONOMY OF STANDBY OIL ENGINES[1]

By W. S. Lea[2]

While there are other methods of arrangement, the auxiliary equipment, as far as the estimates in this paper are concerned, is supposed to be installed as follows:

Gasoline engine prime movers, direct connected to centrifugal pumps, and loaded to 75 per cent of their maximum rating at 1200 r.p.m.

When oil engines, either Diesel or semi-Diesel are the prime movers, two cases are considered, viz.: (*a*) engine driving a centrifugal pump through a double helical gear, and (*b*) engine direct connected to a 25 cycle generator with direct connected exciter. The Diesel engines referred to in this paper are of the four cycle, air injection, trunk piston type.

Estimates have been prepared of the capital costs of auxiliary plants, consisting of two or more units where gasoline engines are considered, and of both one and two units where oil engines are the prime movers.

No reserve capacity is provided for in the engine installation. The engine capacity is based on the efficiencies given below for the equipment which it directly or indirectly drives. Pumps from 65 to 77 per cent; gears, 97 per cent; motors and generators combined, 80 per cent.

Where the auxiliary equipment is in the form of engine driven-pumps, there is an item of expense for piping, which does not occur in the cost of installing engine driven generators. But this is at least in part compensated for, by reason of the fact that when pumps are included in the auxiliary equipment, it is permissible to dispense with a standby unit in the motor driven plant.

In preparing estimates of the capital costs of the auxiliary plants which are of different types and capacities, the method followed was

[1] Abstract of paper read at Canadian Section meeting. Complete article in Canadian Engineer of March 4, 1924.

[2] Consulting Engineer, Montreal, Canada.

to select pumping capacities which would fully load the engines in the sizes available, and plot the plant costs so found against the pumping capacities.

Although each plant is thereby put on the same basis as far as the cost of the most expensive item in it is concerned, other factors entering into the calculations interfere with a fair comparison. For instance, manufacturers adopt certain standards in the way of pump casings, gear boxes, machine frames, etc., which are fitted with motors or running elements of a wide range in capacity. Consequently the price quoted on a machine will appear high or low according as the capacity specified happens to require a casing or frame at its lowest or highest rating.

Moreover, in the more common commercial sizes, the price of a machine on a horse power basis, as a rule falls as the power rises. But a change in price does not follow every change in the rating; it occurs in steps. The Diesel builder, for instance, may lower his price for engines over 100 b.h.p.; the semi-Diesel for engines over 125 b.h.p. In such a case a different conclusion with respect to the relative economy of Diesel and semi-Diesel engine plants, would be drawn from an estimate of a 125 h.p. than from an estimate of a 150 h.p. installation.

In order to eliminate, or at least minimize, the influence of factors of this kind, estimates of each type of auxiliary equipment considered, were prepared for several different capacities, and plotted as mentioned above. It is believed that estimates so prepared afford a fair comparison of capital costs, although it is true that the cost given for a particular capacity, may be found higher or lower than such a plant could actually be built for at current quotations.

The gasoline engine driven plants are of course cheaper than the oil engine installations, but here again the difference is much less than it was a year or two ago.

Auxiliary plants in the form of oil engine driven generators cost roughly 10 per cent more than the oil engine driven pump installations.

The annual interest, depreciation, and maintenance charges have been lumped as a percentage on the total investment; 11 per cent for gasoline engine driven plants; and 10 per cent for oil engine driven plants.

It is presumed that the attendants in the motor driven plant will look after the auxiliary equipment, and with labor eliminated, the

operating charges are confined to the cost of gasoline, fuel and lubricating oils. Fuel oil is taken at 10, gasoline 30 and lubricating oil at 100 cents per gallon, respectively.

The fuel consumption for the 6, 8 and 10 million g.p.d. plants is based on 10 h.p. hours per gallon for gasoline engines, 14 for semi-Diesel, and 17 for Diesel Engines. The work done per gallon of fuel is taken as 5 per cent less than this for the 4,000,000 g.p.d. plants and 10 per cent less for the 2,000,000 g.p.d. plants.

It is assumed that a gallon of lubricating oil is good for 3,000 h.p. hours in Diesel engines and for 1,000 h.p. hours in semi-Diesel and gasoline engines.

Where the electrical power supply to the pumping station is but rarely interrupted, and the auxiliary plant is put into commission only in the event of such a contingency, the annual cost of the plant is largely the fixed charges. For such a service the gasoline engine drive is in a class by itself, so far as the initial and annual costs are concerned.

But with such expensive fuel, the operating cost for gasoline and lubricating oil alone, based on the assumption previously stated, amounts to from $50.00 to $60.00 per million gallons pumped, depending on the capacity of the pumping units. The cost of pumping with gasoline engine driven auxiliaries is from three to five times as great as it is with any other kind of auxiliary equipment considered.

Obviously as the load factor of the auxiliary plant increases, the economy of the gasoline engine driven type fades in comparison with the oil engine driven type.

If it be conceded that there ought to be at least two units in an auxiliary plant, then for a small installation serving about 5000 people, the normal pumping load can be carried by the auxiliaries from five to six hours every day, before oil engines can compete with gasoline engines on an equal basis, so far as total annual costs are concerned.

In larger plants oil engines show to better advantage. A two to three hours daily run is enough to equalize the annual costs when the population served by the plant reaches 25,000. And it so happens that for twice this population half the length of run suffices to give the same result.

It was perhaps hardly worth while bothering with estimates of single unit plants at all. However the data were at hand and under certain conditions one might be inclined to take a chance on a single

unit plant, as for instance when the town is small, is expected to grow rapidly, and there happens to be elevated storage available.

Unless the water has to be pumped against a high pressure it will cost somewhat less to install and operate an oil engine driven auxiliary plant, if the engines are connected to pumps than to generators. But the latter plant is better adapted to a mixed service, where a variety of small powered equipment has to be taken care of.

Oil engine driven generators possess a most important advantage over oil engine driven pumps, in as much as the auxiliary plant can be more fully utilized to flatten the peak in the electrical power load for the whole town. All that the oil engine driven pumps can do is to reduce the peak by the pumping load. This on the average may be taken as equivalent to the normal domestic draft, which for towns with populations ranging from 5000 to 50,000 people, requires only from 25 to 50 per cent of the power installed in the auxiliary plant.

Where the pumping station pressure is boosted for large fires, the normal pumping load may represent still smaller percentages of the capacity of the auxiliary plants.

Peak loads are an important factor in the cost of the electrical power supplied a town, representing a much larger proportion of the power bill than of the energy used. Carrying part of this peak affords a good opportunity for the auxiliary plant, at least in part, to pay for itself.

The common expression "that every case must be considered on its merits," applies to a choice of engines for auxiliary plants. Where the auxiliary plant is to be used simply as a standby, that is to say only when the electrical power fails, it is usually a case for gasoline engine driven centrifugal pumps.

Of course, such a low-powered engine is not well adapted for large plants, but up to capacities of 10,000,000 g.p.d. at 100 pounds pressure, four units suffice and there can be no objection to that many. It must be remembered that usually two of them will carry the load when the power fails.

Gasoline engines cannot perhaps show the best of records as standbys so far as reliability is concerned. Overloading has been partly, if not largely, responsible. However this may be, it was the the only type of standby equipment that many municipalities were disposed to adopt during the last five or ten years. The prices of oil engines are now much more favorable than they used to be, but knowing what their motor-driven plant (which is to them their main

pumping plant) has cost them, the estimates for oil engine driven auxilaries will still often appear formidable to those who have to finance the work.

Where the motor driven pumping plant is supposed to get off the line during peak loads, and there is little or no elevated storage available, gasoline engines are still contenders in the smaller plants. It is not easy, however, to make out a case for them against oil engines, as auxiliaries serving communities with a population of 25,000 people or more.

Semi-Diesel engines do not cost as much as Diesels to install. They run at lower pressures, and have fewer working parts in the way of valves, levers, shafts and cams. They are not, however, so convenient to start, as heat must be applied to the cylinders with a blow torch for a minute or two, unless the engine is equipped with a so-called electric starting device.

At present prices, there is little to choose between Diesel and semi-Diesel engines so far as total annual costs are concerned. It is largely a matter of deciding in any particular case, whether the higher efficiency of the Diesel is worth the additional complications it involves. Obviously the smaller the plant, and the less it is to be used, the better the semi-Diesel engine compares with the Diesel.

DISCUSSION

Mr. Gore suggested that the responsibility for keeping the wheels turning at all times should rest with the Hydro-Electric Power Commission of Ontario and not with the municipalities. The Hydro, he thought, might well afford to install large Diesel-engine standby plants that would avoid any interruption in the current supply.

It is not possible, said Mr. Gore, for oil engines or gasoline engines to compete with the Hydro for normal operation in many towns in Ontario. He had recently considered Diesel drive for one small station, but had found that the establishment and operating charges exceeded by $100 a month the cost of Hydro power. Although gasoline engines are most suitable to installations of comparatively small horse-power, when very large installations are considered it would likely be desirable to install oil engines or steam, because the gasoline engines are not yet made in very large units—not much over 300 h.p., thought Mr. Gore—and it would be too difficult to try to start a number of units in an emergency.

Mr. Lea mentioned the case of one town where he had installed a gasoline engine standby, where the electric plant failed to operate for a month, and the gasoline engine carried the town for the month, running at high speed and heavily overloaded.

Mr. Norman Wilson asked how many gasoline engines would be required to pump 8 m.g.d.

Mr. Lea replied that, considering 8-cyl. engines of 180 b.h.p., direct connected to centrifugal pumps of 70 per cent efficiency, pumping $2\frac{1}{2}$ m.g.d. against 100 pounds pressure or 230-feet total lift, three would be not quite enough and four would be too many.

Mr. Wilson: How many oil engines would be required?

Mr. Lea replied that oil engines are available in nearly any size ordinarily desired for this service. If the town were small and developing rapidly, it would seem desirable to install at least two, each capable of carrying the whole load. Whereas for larger and slower growing communities, three might be better, each 50 per cent of present requirements.

Mr. C. D. Brown enquired whether Mr. Lea knew of any cases where gasoline or oil engines in residential districts had caused complaint on account of an objectionable feature.

Mr. Lea replied that he knew of two cases where noise had caused complaint, and also one case where action had been taken against the muncipality on account of vibration. In this case the ground water was up to the level of the foundation and the vibrations were readily transmitted for 200 or 300 feet. There is no smell, said Mr. Lea, and noise can be taken care of by muffling, with a little sacrafice of power, and if properly installed there should be no vibration.

Mr. Dallyn enquired whether there is any automatic equipment available for the operation of remote stations whereby a standby plant can be cut in or out.

Mr. Lea replied that there are very acceptable methods for remote control of motor-driven pumps, but not of gasoline or oil driven engines. The engines must be started by hand, and when stopped the fuel supply might require attention, and in any event nobody would care to leave a 6, 8 or 10 m.g.d. plant running without an attendant.

Mr. Ray Knight enquired whether for small municipalities an ordinary motor truck would not suffice as a standby motor for a waterworks pumping plant. He suggested that the truck be backed into the plant, jacked up and a belt put over the wheel.

Mr. Lea replied that one of the main objects of standby units is to comply with the requirements of the fire underwriters, so that a better fire-insurance rate can be obtained for the municipality; and the underwriters will not permit a belted connection of any kind—not even a belted exciter for a generator—and moreover would undoubtedly object to the truck idea anyway, as the truck might not be there when wanted. In any event a 40-h.p. gasoline engine is not a great expense, and that is all the power that a truck would likely afford.

Mr. Darling said he had installed one station where, if fires had occurred during the town's peak load, and the pumps had been motor driven, each fire would have cost $300 for electric power, on account of boosting the peak. That would pay for 1000 gallons of gasoline.

Mr. Dallyn: How often should auxiliary units be tested? Is once a week satisfactory?

Mr. Lea: At least once a week.

Mr. Wilson: We turn our engines over every day.

Mr. A. U. Sanderson: In the Toronto plants every unit is tested once a week, and once a month it is placed under full load for a considerable period. This involves considerable work in switching, but in a large plant, it is very advisable. What developments have there been in the manufacture of units of large capacity, say 5000 h.p.

Mr. Lea: Oil engines have been made up to 6,000 h.p., and some manufacturers had developed up to 1000 h.p. per cylinder. It is only a question of using enough cylinders. I do not know the possible limits.

Mr. W. G. Chace raised a point in connection with the parallel operation of centrifugal pumps, one motor driven and one oil-engine driven, to keep down peak-load costs.

Mr. Lea: With the same pumps and the same conditions, just as good results could be obtained with oil engines as with motors, in parallel operation.

Mr. Chace said that with motors there is an electrical interlock as to speed. With an oil engine this speed regulation is not so easy and the motor might not get the expected relief unless the units had careful adjustment throughout operation.

Mr. Lea replied that the operator can readily see the speed at which his oil engine is running and that it is easy to regulate it without delay, and with proper governing system the speed should be maintained very accurately.

Mr. H. G. Hunter said that at the Cartierville filtration plant he connected the exhaust to the wash-water drain line and one cannot hear the unit running. At other plants he has connected the exhaust into a chimney, or installed a pit 3 or 4 feet square, 4 feet deep, covered with a grating and filled with stone and exhausted to the bottom of the pit. The pit must be drained, of course.

At Cartierville the operator fell asleep one night while filling his clear-water basin, and the overflow put three motors out of commission for sixteen days. The Sterling engines ran the 7½-h.p. low-lift pump and the 85-h.p. high-lift pump almost continuously during that period, the longest non-stop run being 56 hours.

Mr. R. Walters said that a rumbling noise is noticed in some of the Leamington residences at times. The vibration is not due to water hammer, he thought, but more likely to air in the lines. All their mains are laid in ground water. They have reservoirs, steam plunger pumps, no gear drive, no high suction lift, and have not been able to trace the trouble.

Mr. Harry F. Huy said that he had found rumbling in one case to be due to a vacuum pump in a heating system in a large school. Where plumbing is loosely installed anywhere in the town, vibration can be transmitted for a long distance.

Mr. Walters: Our trouble is sometimes in one part of the town and sometimes in another section.

Mr. Robt. Dyson suggested that there might be a deficiency in the air chambers of the pump.

Mr. Kellner said that the noise usually is not in the mains, but in the house plumbing. Several cases were investigated in Windsor and the plumbing was found to be quite loose. In one case the screw of the faucet spindle was very loose. When using centrifugal pumps, vibrations are transmitted along the line and are augmented by any loose plumbing which can vibrate in unison.

Mr. Gore stated that similar trouble had been experienced near the Sunnyside station in Toronto, where a number of houses had been disturbed for a long period. The trouble had been investigated by Mr. Milne, mechanical engineer of water works, who had come to the conclusion that it was due to certain dead ends.

There are always oscillations in water mains, and dead ends can readily cause trouble. In London investigation of disturbances due to reciprocating engines clearly showed waves and nodes of vibration, and it has been necessary in one case to build special rubber-mat foundations for the units.

Mr. Starr said that he has a 5-gallon tank inside the building, fed by hand pump.

Mr. Dyson said that last July they had installed two 8-cylinder gasoline engines and had been informed that they would be required to have at least thirty-six hours' supply of gasoline on hand. After considerable correspondence, the underwriters had consented to cut this down to twenty-four hours. The gasoline engines are used whenever a fire alarm comes in, as their bill would be boosted $75 to $90 for twenty minutes' operation of the pumps during a peak load, and in any event no water is used for 75 per cent of the alarms, so that the average run is very short, and it has been found desirable to use the standby units. So far there has been no complaint from the underwriters.

Mr. Hunter explained the requirements of the underwriters in Quebec. A storage tank must be 16 feet from the building, and underground. An auxiliary tank is fed by a hand pump. The piping must be of copper with soldered joints. No gasoline must be left in the unit after the run is finished, but must be drawn back into the storage tank.

A NEW DIFFERENTIAL TEST FOR MEMBERS OF THE COLON GROUP OF BACTERIA

Stewart A. Koser[1]

It is now well established that the "B. coli" of the earlier workers in the field of sanitary bacteriology was in reality a broad group of organisms, the members of which are encountered in widely different habitats in nature and which differ from one another in many minor characteristics. The desirability of classifying this group became evident at an early date, for it was recognized in sanitary water work that certain members of the group might be more significant than others as indicators of pollution. The earlier attempts at classification were founded largely upon the qualitative fermentation of sugar media, chiefly sucrose, dulcitol, mannitol, raffinose, inulin, and salicin. On the basis of these fermentations, together with certain cultural tests, several elaborate classifications of the group were made. In general these classifications were highly artificial, numerous varieties of "B. coli" were created and there was no striking correlation between these varieties and the natural habitat of the organisms.

A most valuable contribution to the subject of water bacteriology was made about ten years ago by Rogers and his associates (1) who showed that on the basis of dextrose metabolism the colon group, or colon-aerogenes group as it is sometimes called, may be divided into two chief subgroups, the Bact. coli and the Bact. aerogenes sections. Subsequent work (2) has demonstrated that the differences in dextrose metabolism manifested by these two subgroups may be brought out in several ways: first, by determination of the ratio of gases ($CO_2:H_2$) evolved during anaerobic fermentation, second, by determination of the acidity in a special dextrose medium (the well-known methyl red test) and, third, by the Voges-Proskauer reaction. It has also been found (3) that the coli type may be separated from the aerogenes section of the group on the basis of the utilization of uric acid. The intestinal Bact. coli refuses to develop in a synthetic uric acid medium while the members of the Bact. aerogenes grow readily.

[1] From the Department of Bacteriology, University of Illinois, Urbana, Ill.

The natural habitat and the present methods of differentiation of the two chief sections of the colon group may be summarized as follows:

	SECTIONS OF THE GROUP	
	Bact. coli	Bact. aerogenes
Habitat	Constitutes about 95 per cent of the colon group organisms in the feces of man and warm blooded animals	Predominating type in soil and on grains. Occasionally found in intestine
Differential methods:		
Methyl red test	Positive (acid)	Negative (alkaline)
Voges-Proskauer reaction	Negative	Positive
Gas ratio CO_2:H_2	Low ratio, 1:1	High ratio, 1:5 or more to 1:0
Uric acid medium	Negative (no growth)	Positive (growth)

Atypical cultures as well as variations in these tests have been reported by most of those who have worked extensively with this group of organisms. However, these atypical forms constitute only a small per cent of the colon group cultures usually encountered so that as a general rule the above methods of differentiation serve nicely.

In spite of these differences between the two sections of the group, the desirability of their use in practical sanitary water analysis is still a disputed point. The determination of the gas ratio is a cumbersome procedure requiring special apparatus and is out of the question in the ordinary laboratory. Of the remaining tests, the methyl red and Voges-Proskauer tests are the best known and the most commonly used. In recent years they have been tried in water work but their practical value seems to be unsettled, some workers claim that they add nothing to the accepted methods of bacteriological water analysis, while others state that they are of definite value.

It is the purpose of this paper to call attention to a new differential test which is somewhat simpler than the former ones and which may prove to have some practical value. Briefly, it depends upon the inability of the intestinal Bact. coli to utilize citric acid, or sodium citrate, as a source of carbon, whereas the aerogenes section does

attack and utilize the citrate. In a simple synthetic medium containing a citrate as the only source of carbon the intestinal Bact. coli refuses to grow and the culture tubes remain clear. On the other hand, Bact. aerogenes and related types develop quite readily, the tubes become turbid after 24 to 48 hours and at the third or fourth day there is usually a heavy growth. This difference may be brought out very easily by either one of the following synthetic media:

I.	Distilled water	1000 cc.
	NaCl	5.0 grams
	$MgSO_4$	0.2 gram
	$(NH_4) H_2PO_4$	1.0 gram
	K_2HPO_4	1.0 gram
	sodium or potassium citrate	2.0 grams
	(sodium citrate · $5\frac{1}{2}$ H_2O	2.77 grams
	or potassium citrate · H_2O	2.12 grams)
II.	Distilled water	1000 cc.
	$Na(NH_4) HPO_4 + 4 H_2O$ (microcosmic salt)	1.5 grams
	KH_2PO_4	1.0 gram
	$MgSO_4$	0.2 gram
	(sodium or potassium citrate as given in I)	

If desired, 2 or 3 grams NaCl can be added to the second combination to make the medium more nearly isotonic. It is important that no carbon-containing compounds other than the citrate be present since they might permit the development of the coli type and thus obscure the differentiation. Both of the foregoing media are clear and colorless and require no adjustment of the reaction. The hydrogen-ion concentration is slightly on the acid side of neutrality, pH 6.6 to 6.8. They are filled into ordinary test tubes in 5 to 8 cc. amounts, sterilized in the autoclave at 15 pounds pressure for fifteen minutes and after cooling are ready for inoculation. These media have been used for the past two years by the writer in studies of the colon group (4) and have been found to constitute a very simple method of distinguishing fecal Bact. coli from other members of the group.

The citrate differentiation is perhaps somewhat easier to apply and appears to possess certain advantages over the methyl red and Voges-Proskauer tests. Either of the citrate media can be readily prepared by simply dissolving the salts in the required amount of water. The medium required for the methyl red and Voges-Proskauer tests is composed of Witte's peptone or a special proteose peptone and, fur-

thermore, variable results are sometimes secured by the use of different peptones. In the citrate medium crystalline salts are used entirely, thus doing away with any complex and perhaps variable substances such as proteoses and peptones. In addition, the results in the citrate medium can be determined at a glance, whereas to complete the methyl red and Voges-Proskauer tests it is necessary to add certain reagents—either methyl red indicator or potassium hydroxide—to the cultures and then record the results, in the case of the Voges-Proskauer test after allowing the tubes to stand for some time.

Another point of interest in regard to the citrate test is in the differentiation of certain soil organisms very closely resembling the fecal Bact. coli. In the examination of unpolluted woodland and forest soils by the writer (4), colon group organisms were frequently encountered and among them were a number of cultures which were methyl red positive and Voges-Proskauer negative. That is, on the basis of these two tests these organisms would be classed as fecal Bact. coli. However, when these cultures were tested in the citrate medium, practically all of them developed readily and in this respect they were distinct from the typical intestinal Bact. coli.

In the past it has been commonly assumed that all methyl red positive colon group cultures encountered in water, soil and other situations in nature outside of the body were of intestinal origin, even though remotely removed from any evident source of pollution. Upon applying the citrate test, however, most of these methyl red positive soil organisms could be distinguished from the fecal Bact. coli. The relationship of the citrate differentiation to the habitat of the organisms and to the methyl red and Voges-Proskauer tests may be shown as follows:

	INTESTINAL (BACT. COLI FROM MAN AND ANIMALS)	SOIL ORGANISMS	
		Intermediate (?)	Bact. aerogenes, etc.
Methyl red	+	+	−
Voges-Proskauer	−	−	+
Citrate medium	− (no growth)	+	+

The organisms recovered from soil which resemble the intestinal coli in respect to the methyl red and Voges-Proskauer tests are shown in what is tentatively designated as an "intermediate" section.

These were encountered less frequently than the Bact. aerogenes section, but were nevertheless found in appreciable numbers and seem to stand apart as a separate section. Their differentiation from the typical fecal Bact. coli on the basis of the citrate test is quite distinct, for they apparently grow as readily in the citrate medium as do the members of the aerogenes section.

While in the foregoing table the three different types are shown as sharply defined sections or subgroups of the colon group, as a matter of fact a few intermediate or irregular cultures are usually encountered. Practically all previous investigators who used large collections of colon group cultures found at least a few individuals which gave irregular or atypical results with the methyl red and Voges-Proskauer tests. The same holds true for the citrate test. In a collection of over 200 cultures isolated by the writer from feces, water, and soil, several irregular types were found. Two fecal coli cultures developed in the citrate medium; one culture, apparently Bact. aerogenes, failed to utilize citrate; also, one or two cultures were found which were difficult to place in any section on the basis of the differential tests. On the whole, irregular or atypical cultures were encountered infrequently and did not detract from the value of the test. As with all biological work a few intergrading or intermediate forms must be expected. In the series of colon group cultures collected by the writer the greatest amount of variation was found to be in the deportment of the soil cultures toward the methyl red and Voges-Proskauer tests.

The citrate test, in view of its simplicity and its promise of value in separating the fecal Bact. coli from other members of the group, seems deserving of further study by those interested in sanitary bacteriology. It should be pointed out that the citrate test, as with the other differential tests, should be applied only to pure cultures of colon group organisms. Thus, in following the standard methods of water analysis (5), lactose broth tubes which have been inoculated with the water sample in question and which show fermentation are streaked upon Endo plates or eosin-methylene blue plates. From colon-like colonies on these plates, agar slants and second lactose broth tubes are inoculated to finish the "completely confirmed" procedure. If the differential tests are applied, it is from these same colonies that tubes of citrate medium and medium for the methyl red and Voges-Proskauer tests should be inoculated. To obtain data of any value a series of colon cultures from each water sample,

wherever this is possible, should thus be isolated and run through the differential tests.

At the present time, the greatest need would seem to be the study of the occurrence of the several types of colon group organisms—as determined by the differential tests—in different classes of natural waters of known sanitary quality and the correlation of these data with the sanitary survey.

REFERENCES

(1) Rogers, L. A., et al.: Jour. Infect. Dis., 1914, vol. 14, 411; vol. 15, 99; vol. 17, 137; Jour. Bact., 1918, vol. 3, 231.
(2) Clark, W. M., and Lubs, H. A.: Jour. Infect. Dis., 1915, vol. 17, 160.
Levine, M.: Jour. Infect. Dis., 1916, vol. 18, 358; Jour. Bact., 1916, vol. 1, 153.
Johnson, B. R., and Levine, M.: Jour. Bact., 1917, vol. 2, 379.
(3) Koser, S. A.: Jour. Infect. Dis., 1918, vol. 23, 377.
(4) Koser, S. A.: Jour. Bact., 1923, vol. 8, 493; 1924, vol. 9, 59.
(5) A. P. H. A. Standard Methods of Water Analysis, 1923, p. 108–110.

THE MOST INTERESTING EXPERIENCE RECENTLY ENCOUNTERED IN WATER TREATMENT[1]

THE EFFECT OF LARGE RESERVOIR ON WATER SUPPLY QUALITY

Mr. James W. Armstrong:[2] I wish to say a few words regarding the changed condition in operating Montebello Filters, caused by raising Loch Raven Dam a height of 52 feet. The day before I started for the water works convention one year ago, water flowed over the crest of our new dam for the first time, thus filling to the brim an impounding reservoir covering about 2500 acres of land and holding 23,000,000,000 gallons of water. The country surrounding the new reservoir is hilly and very irregular in shape; consequently, there are many inlets and little coves into which the water is backed. Many of the coves are quite shallow and are very favorable for the growth of all kinds of organisms. When it is understood that the shore line is about 50 miles long and that before flooding the ground was covered with vegetation, it can easily be seen what a tremendous opportunity for the growth of vegetable and animal life the new reservoir presents.

This will be especially appreciated when it is understood that the raising of the water surface has greatly increased the cross sectional area of the stream and has very much reduced the velocity of flow, so that the movement of the water in the broad expanses and in the coves is caused principally by the wind.

The covering of this large area of ground with water has to a large extent changed its character, and has in many ways changed operating conditions at Montebello. I have taken from our records a few figures which show what the changes in water conditions have meant in the way of plant operation. In using these figures, it should be borne in mind that they are monthly averages and do not represent any extremes. Therefore, they are better for general comparison. I have compared the years 1920 and 1921 with the

[1] Presented before the Chemical and Bacteriological Division, New York Convention, May 21, 1924.

[2] Filtration Engineer, Water Department, Montebello Filters, Baltimore, Md.

year 1923, omitting the year 1922, for during 1922 the reservoir was in the course of filling and represented a transition period. In order to show at a glance what the flooding of the new area has meant in plant operation, I am showing the results in two columns, one of which lists the increased difficulties encountered and the other shows the gains.

Gains	*Losses*
Cooler water	More organisms
Reduced turbidity	Poorer floc
Fewer bacteria	Shorter filter runs
Fewer colon bacteria	Clogging of sand
Less chlorine required	Trouble with manganese
Less alum required	
Freedom from sudden changes	

Cooler water. In comparing the temperature of the water, averages were taken for the months of June, July, August and September. During the winter months there was very little change. By comparing the figures, it will be noted that there was a net average gain for the four months of 6° F. in the coolness of the water.

	1920	1921	1923
	°F.	*°F.*	*°F.*
Average air temperature	74.35	75.9	74.65
Average water temperature	72.00	73.5	66.22
Net gain in coolness	2.35	2.4	8.4

Turbidity. The mere comparison of turbidities does not tell the whole story due to the changed conditions. While the reduced turbidity did result in a large saving of alum, the gain was not proportional to the reduction, as it took more alum to form a good floc, and the floc was looser and more easily broken up than formerly. The looseness of the floc was clearly revealed under the microscope, and by means of laboratory tests it was proven that the floc was readily broken upon striking the filter sand. The average reduction in turbidity from about 85 to 8.5 has resulted for the year 1923 in saving 4300 pounds of alum per day, which at a price of $23.00 per ton makes a total saving for the year of $18,000.00.

From an operating point of view, the reduction in turbidity and the freedom from sudden changes has proven a great blessing to the laboratory force and the men who mix and handle chemicals, as it

has relieved them of practically all anxiety formerly caused by the uncertainty as to what was going to happen next. There are now no calls in the middle of the night when a sudden storm occurs.

	1920	1921	1923
Average turbidity	91	79	8.4
Maximum turbidity	231	459	11.0
Average alum, grains per gallon	1.29	1.04	0.87
Maximum alum, grains per gallon	2.14	2.51	1.42

Fewer bacteria. The reduction in bacteria was very marked in both the 20° and 37° counts and also in B. coli. The higher forms of organisms which were so prevalent in the water destroyed many, and the sunshine and wind also played a part.

	1920	1921	1923
Bacteria per cubic centimeter 20°C. raw water			
Average	16,189	5,438	218
Maximum	85,687	38,043	528
B. coli per cubic centimeter raw water			
Average	41.13	58.60	0.93
Maximum	130.04	183.47	2.27

Organisms. As the flooded area covered nearly 2500 acres, and the stream flow was such that it took months to fill the reservoir, it presented an unusual opportunity for the growth of organisms. The multiplication of these organisms troubled us in two ways: first, in our settling basins, and second, with the filter sand. It was also thought that the presence of so many organisms interfered to some extent with the proper action of alum as a coagulant, as the increased amount of alum necessary to secure a proper floc could not be accounted for by comparing the required amount with the turbidity curves established by past experience.

After the water began to rise in the new reservoir, great numbers of Bryozoa were noticed in the water. These organisms coming in fairly large masses were generally precipitated in the coagulating basins where they settled to the bottom and went through a process of decomposition. The resultant gas formed, caused particles of

sludge to rise to the top of the basins, resembling very much the sludge that rises to the top of sewage septic tanks. It was not only unsightly but cast off an offensive odor, which necessitated our cleaning the basins several times when there was only a slight deposit on the bottom.

Other types of organisms, principally a slime-producing bacterium not yet identified, passed on to the filters and began to coat our sand grains. These growths did not seem to injure the quality of the water, but were first made apparent by matting and ridging the sand. The sticking together of the sand particles reduced the area available for filtration and shortened the filter runs to such an extent, that it was hard to secure enough water for supplying the city.

In order to clean the sand it was washed through an ejector and a Nichols sand washing machine. This relieved our troubles for a time, but during the hot season of the year the sand grains became recoated rapidly. With the advent of cold weather this trouble ceased to a very large extent.

	1920	1921	1923
Organisms in raw water			
Average number per cubic centimeter	163	259	4724
Maximum, number per cubic centimeter	457	954	12590
Length of filter runs			
Average time, hours	36.9	62.7	25.5
Maximum time, hours	60.2	100.1	37.1

An inspection of the list of organisms occurring in the greatest numbers reveals the fact that most of them belong to the animal kingdom. The presence of such large numbers of the higher type of microscopic organisms in the water means that there must also be an abundance of the lower forms to serve as a food supply. The problem of ridding the reservoir of organisms seems to be the one of preventing the growth of such forms as "algae," which thrive particularly in the warm shallow water.

In order to get rid of such places, we plan to purchase a small suction dredge boat with which we can deepen the shallow places, and fill in the low marshy places along the shore. It is believed that by deepening the shallow places, much good will be done toward purifying the water at the source.

FIG. 1. SLUDGE ON THE SURFACE OF THE COAGULATING BASIN, MONTEBELLO FILTERS, CAUSED BY DECOMPOSING ORGANISMS

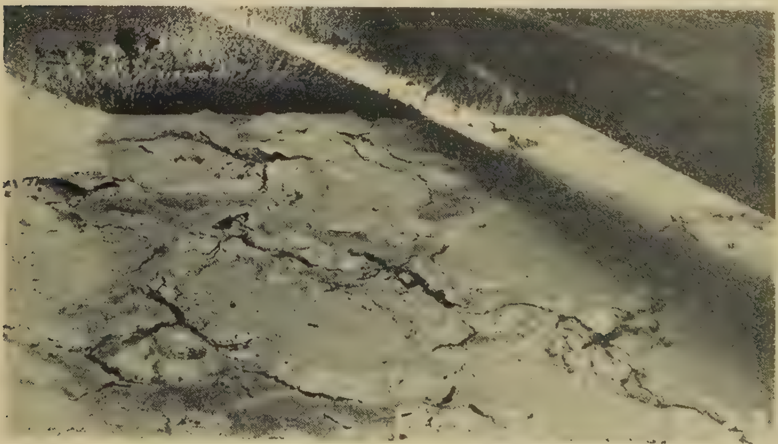


FIG. 2. MATTING AND RIDGING OF FILTER SAND CAUSED BY ORGANIC GROWTHS ON THE SAND GRAINS

Organisms showing great increase after raising water level in Loch Raven reservoir

Diatoms:	Nemotodes
Melosira distans	Rotatoria:
Fragilaria	Polyarthra
Asterionella	Anuraea
Algae:	Pedalion
Staurostrum	Cladocera:
Protozoa:	Daphnia
Difflugia	Bosmina
Uroglena	Copepoda:
Dinobryon	Cyclops
Peridinium	Bryozoa:
Vorticella	Paludicella
Epistylis	Pulmatella polymorpha
Hydra:	Corethra (larva)
Porifera:	
Tubella pennsylvania	

Manganese. There is always something happening around a filter plant. Just as things seemed to settle down to smooth running, complaints began to come in from housekeepers that bath tubs were being discolored, and from laundries and hospitals that their linen was being stained. Investigation proved that the trouble was due to the presence of manganese in the water which had been absorbed from the rocks and soil of the freshly covered area. Mr. Baylis, who is to follow me, will tell more particularly what this trouble meant.

MANGANESE IN BALTIMORE WATER SUPPLY

Mr. John R. Baylis:[3] A sudden and unexpected increase of manganese in the Baltimore water supply in 1923, caused many complaints of it staining clothes and white enameled water fixtures. Most of the complaints were received during the months of October and November, being somewhat delayed from the time the increase started. The delay of complaints was due to the fact that it required some time for the stains to become noticeable, and that most of the laundries and other industries affected were looking for the trouble in their own plants. The increase was detected the first of August in searching for the cause of an interference with the ortho-tolidin test for residual chlorine. Black looking suspended particles helped

[3] Principal Sanitary Chemist, Water Department, Montebello Filters, Baltimore, Md.

to confirm our suspicion that something unusual was wrong. From occasional tests we were aware that the water contained small quantities of manganese, usually less than 0.1 p.p.m., but daily determinations were not being made at the time the increase started.

When the increase was detected no immediate attempt was made to remove it. In fact, we did not know the amount necessary to cause trouble, nor the extent of such troubles. The first complaint was from a dyeing plant the latter part of September, nearly 2 months after the increase started. Their chemist visited the filter plant to see if we could give any clue as to what might be staining his fabrics. About 2 weeks later the manager of a small laundry reported that clothes were being stained a brownish color in spots. A visit to the plant confirmed the fact that he was having serious trouble. The Water Engineer then immediately notified all laundries of the presence of manganese in the water. This gave them an excuse to offer many indignant customers and to apply, as far as possible, local remedies.

Cause of the sudden increase of manganese. To explain such a sudden increase in water from a source that has been used for a number of years without another objectionable occurrence has necessitated a careful study of all conditions that have been changed by the improvements on the Gunpowder River within the past few years. There is fairly conclusive evidence that manganese has not occurred previously in quantities greater than 0.2 p.p.m., except possibly in the fall of 1922. The water level in the Loch Raven reservoir on the Gunpowder River was raised about 10 feet above its previous level in the spring of 1922, and about 40 feet in the early part of 1923. There was considerable trouble from the filter beds clogging in 1922, and the dark incrustation around the sand grains seemed to increase slightly, but only one complaint of the water staining clothes was received. The manganese might have gone a little higher than usual in August and September, 1922, but it did not go nearly so high as it did in 1923.

All the main streams entering the Loch Raven reservoir were free from manganese in quantities over 0.1 p.p.m. when tested on 2 different occasions at the time the increase was highest. The reservoir was free from manganese in the part of it just above an old mill dam which is now submerged a few inches. This dam is near the upper part of the reservoir and is across the river that supplies about three-fourths of the water. Since the streams entering the

reservoir are practically free from manganese it makes the proof almost conclusive that the manganese is coming from the rock underneath. Years ago there was an iron furnace operated at Ashland, a small village on the Gunpowder River and now near the upper part of the reservoir, but below the old mill dam. The ores were obtained in that vicinity, and we are reliably informed that the iron contained considerable manganese. All rock examined from the vicinity of the reservoir has been found to contain small quantities of managanese. The chemical combination in which it occurs is not known, but it is most likely an oxide or carbonate. Either is slightly soluble in the presence of certain organic acids. From the fact that manganese resembles iron somewhat it is likely the acids which will dissolve one will dissolve the other.

We are aware of the fact that the oxides of iron are dissolved under certain conditions. Harder (1) states that the iron compounds are dissolved by the action of acids present in ground and surface water. The principal acid in ground water is usually carbonic, but variable amounts of other acids such as butyric, propionic, formic, citric, lactic, acetic, tartaric, valerianic, humic, crenic, aprocrenic and ulnic may be present. They are largely the results of decay of organic matter by biological action. Marshall (2) states that organic acids are formed by nearly every important species of soil bacteria, and that the tissues of dead plants and animals are not the sole source of organic acids in soils. He also states that they are not likely to accumulate in well ventilated soils as molds and other bacteria destroy the acids rapidly. This offers excellent proof of why the organic acids become more concentrated when the air is excluded, and may offer a clue as to why certain organisms precipitate iron and manganese. They may break down the complex and soluble organic acid compounds of iron and manganese. Löhnis and Fred (3) give carbon dioxide and humus as the main products formed by bacterial action on decaying vegetation, but they state that organic acids, alcohols, methane and hydrogen may appear as by-products. Moody (5) says that carbonic acid exerts a great corrosive influence on iron, which may be even greater than hydrochloric or sulfuric. The oxides of iron are not attacked very readily by carbonic acid, and while the most of the soluble iron in water is supposed to be a bicarbonate of iron the proof we have is none too positive. We are aware that some of the other organic acids are more effective in dissolving the oxides of iron and manganese. Kendler (5) as early as 1836 called attention to the fact that decaying vegetable matter has a marked effect on the solubility of ferric hydroxide. He noticed that ferruginous quartzose sand was rendered colorless around decaying roots and in a few months became as white as if it had been treated with an acid. A root $\frac{1}{6}$ inch in diameter, upon decaying, whitened the sand to a distance of 1 to 2 inches around it. The writer has not been very successful in dissolving sterile oxides of iron and manganese with carbonic acid, but when a little beef extract and peptone was added to the solution and inoculated with water from in contact with sand from one of the filters, a biological

action took place which dissolved considerable iron and manganese. It has been found that particles of decaying organic matter, such as small fish, will cause sand heavily coated with iron and manganese to become almost white for an inch or more around the particle when found in clogged places in the filter beds.

When the surface soil in the Loch Raven reservoir was covered with water, conditions became favorable for certain biological actions to take place, which formed organic acids. The surface soil with the decaying vegetation produced a zone requiring considerable dissolved oxygen to take care of the biological actions. The diffusion of oxygen was not rapid enough for it to pass this zone, resulting in the water in contact with the earth and rock underneath having no dissolved oxygen. The demand for oxygen may have been so great in order to complete the process of decay that the oxides were reduced. If the oxides are reduced they are very likely more soluble with carbonic acid, which is always present under such conditions. Hawley (6) states that the oxides of manganese are readily dissolved by citric acid. This has been confirmed in our laboratory by using lemon juice. Tartaric acid also dissolved manganese from the sand grains very readily.

The diffusion of soluble manganese to the surface has probably been taking place since the water level was raised. Part of it was deposited near the surface of the top soil when it came in contact with dissolved oxygen. The precipitation at this point was probably aided by certain biological growths. As it passed through the tunnel, about 8 miles long from the reservoir to Montebello Filters, more of it was deposited on the sides of the tunnel by a luxuriant growth of schizomycetes. About the first of August, 1923, slime-producing bacteria started to grow on all surfaces in the reservoir, tunnels, basins, etc. The growth on the sand grains was delayed slightly on account of chlorine being used before filtration from July 28 until August 14. A previous occurrence of these bacteria in August and September, 1922 caused us to be on the lookout for them. Figure 1 shows camera lucida drawing of a sand grain made September 27. These bacteria require oxygen, and there was considerable reduction of the dissolved oxygen when they were present. For the month of October, 1923, the dissolved oxygen was only 35 per cent saturation, which is considerably lower than the average for the past 4 years. The oxygen demand of these bacteria is so great that filters, operated at the rate of 25 million gallons per acre per day, or

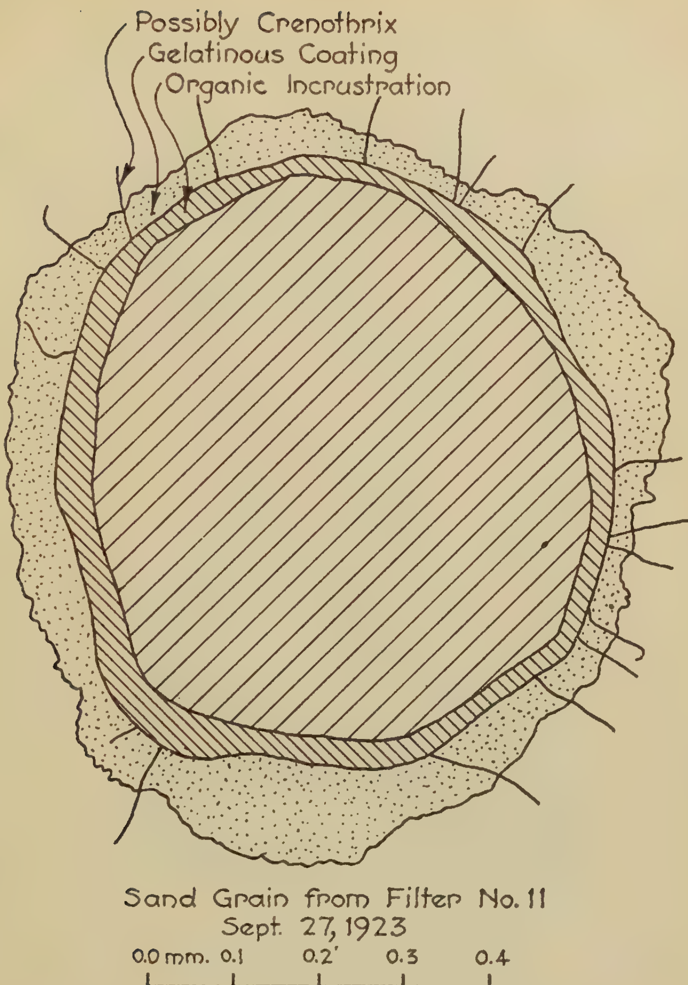


Fig. 1

There is evidence that the gelatinous coating started to grow on the sand grains during the latter part of August. Drawing of a grain dated August 23 shows no coating. This was ten days after stopping the application of chlorine to the raw water. The gelatinous g owth has killed out most of the filamentous growths which were so numerous during the summer. This coating has not only covered the sand grains, but all surfaces in contact with the water.

about one-fifth normal rating, removed practically all dissolved oxygen from the water passing during times of excessive growths.

In covering the deposited manganese with a coating of slime, the bacteria produced conditions favorable for it being thrown into solution. The bacteria may grow more abundantly on oxides that can be reduced. The biological action not only prevented the manganese being derived from the rock underneath being deposited, but added materially to the amount by dissolving that already deposited. It is very probable that such a condition has happened at other places, as the fluctuating manganese contents of several water supplies give added proof. The water at the outlet of the tunnel about 7 miles long contained more manganese than the water entering, indicating that the manganese deposited on the sides of the tunnel was also being thrown into solution. The soluble manganese was also increased in passing the filter beds. Holding samples of sand from the filter beds submerged in water and the air partially excluded for a week or more the black oxides of manganese gradually changed to a dull red, indicating the possibility of a reduction from MnO_2 or Mn_2O_3 to Mn_3O_4. No attempt was made to prove positively that such a reduction took place, but the solution contained about 10 p.p.m. of soluble manganese. This experiment was repeated a number of times and in every case when the sand was covered with the slime there was an increase of soluble manganese. Before testing for soluble manganese the solution was coagulated with alum and filtered through paper, and as the filtrate was perfectly clear there can be no doubt about it being in solution. Sand from any of the filter beds when the grains were covered with the slime as shown in figure 1 would give up from 1 to 2 p.p.m. manganese in 48 hours when about twice the volume of water to that of sand was added. It is probable that the slime-producing bacteria produced acids other than carbonic, for carbonating water in contact with manganese dioxide did not cause much more than a trace to be dissolved. That the manganese is thrown into solution is proven beyond a doubt, but the cause for precipitation is not so easily proven. Oxygen plays an important part, yet it will not cause the precipitation of any of the soluble or slightly soluble compounds of manganese. It is an essential, but it seems that something other than oxygen produces the hydroxide of manganese.

The photograph in figure 2 was made to show the shrinkage of badly coated sand from one of the filter beds by increasing the loss of head

when filtering. A few inches above the sand surface is noted an incrustation of manganese. About the first of September, 1922, the tube was filled with sand to a point opposite 5.1 feet on the level rod, which

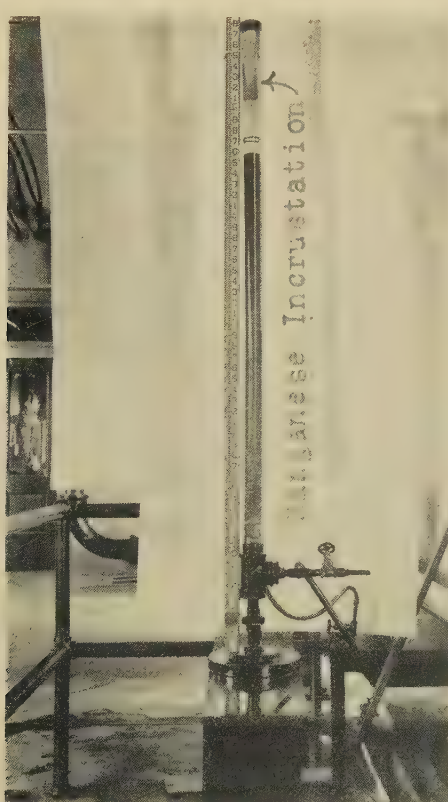


Fig. 2. Manganese Incrustation on Glass Tube Containing Sand—Experimental Filter

About the first of September, 1922, sand from one of the filter beds was placed into the glass tube, thoroughly washed and allowed to stand five days. The surface of the sand after washing was opposite 5.1 feet on the level rod, or at the bottom of the manganese incrustation. Within two or three days a dark-brown incrustation started to form just above the sand surface.

is the bottom of the incrusted place, and after thoroughly washing it was allowed to stand undisturbed for about five days. A dark brown incrustation formed on the inside of the glass tube. It was thickest at the sand surface and gradually got lighter until there was practically

none 6 inches above. In attempting to wash the sand it was found that the top 3 inches adhered into a solid mass. The coating of manganese was probably deposited above the sand surface by the same process it was deposited in the Loch Raven reservoir. The biological action taking place beneath the sand surface consumed all the dissolved oxygen and probably liberated acids that dissolved some of the manganese. The soluble manganese, probably in chemical combination with a complex organic acid, diffused to the water above the sand containing dissolved oxygen. There may have been an oxidation, or breaking down, of the organic acid which released the man-

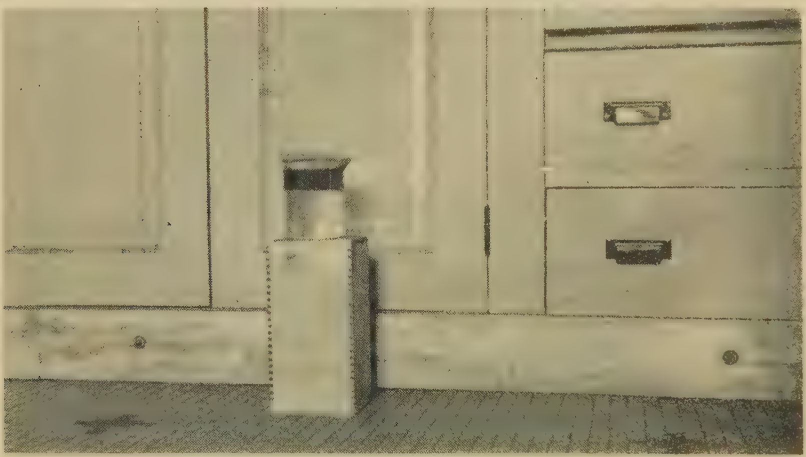


FIG. 3. MANGANESE INCRUSTATION CAUSED FROM A BIOLOGICAL ACTION

Sand from one of the filter beds was allowed to stand in the beaker for two weeks. The biological action taking place dissolved the manganese coating from around the sand grains, and it was deposited on the top of the sand and the sides of the glass above the sand.

ganese in an insoluble form, or certain manganese precipitating bacteria aided in the action. A number of experiments thoroughly confirms the fact that manganese may be readily precipitated in this manner. The fact that there was evidence of biological growths in the precipitated film on the side of the glass and the sand surface indicates that there might have been another biological action causing the precipitation. There are indications that the production of acids that will dissolve manganese is limited to a few species of bacteria, for it is only at certain times of the year that such a phenomenon will take place. In fact it is believed that one specie of bacteria has been responsible in the experiments conducted.

Biological Growths. Biology has evidently played such an important part in causing this trouble that it may be well to give some of the principal changes that have taken place since the water level was raised in the Loch Raven reservoir. A fairly complete record of the microörganisms in the water coming from the Loch Raven reservoir has been kept for several years. This, however, gives very little

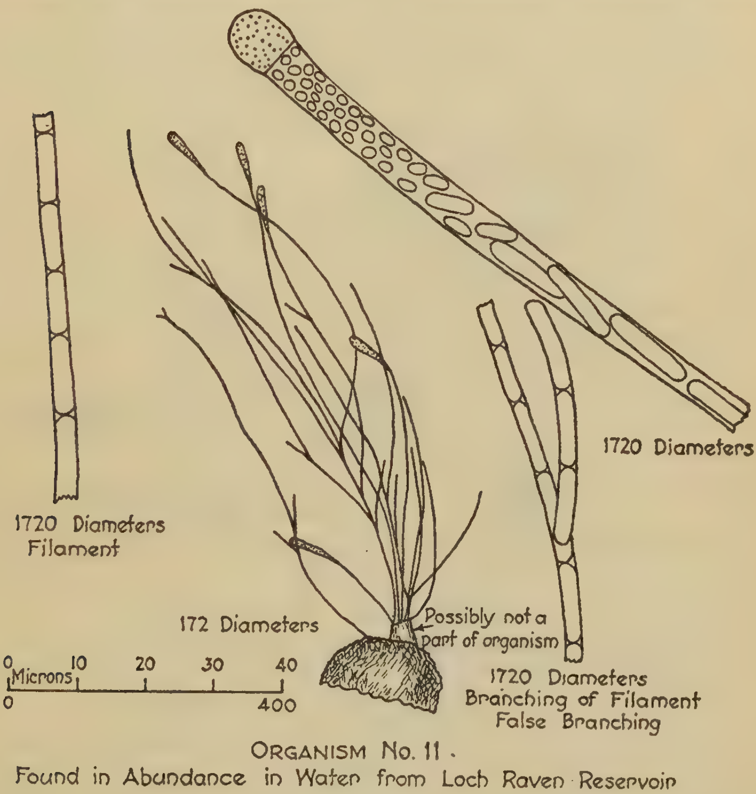


FIG. 4

information as to what is actually taking place in the reservoir. The chief change in 1922 and 1923 due to raising the water level was an increase of bryozoa, crustacea and other animal organisms. In the summer of both years, there was an abundance of filamentous organisms, mostly species of schizomycetes and molds, followed by a luxuriant growth of slime producing bacteria. Figures 4 and 5 show species of filamentous organisms occurring in great abundance both years.

The one shown in figure 5 precipitates iron and manganese. The slime producing bacteria started to grow in August of both years, and were very abundant in 1923. They covered all surfaces in the Loch Raven reservoir, tunnel, settling basins and filters. Figure 6 shows how badly coated were some of the sand grains in the filter beds. Figure 7 is drawing on a larger scale showing the bacteria. Attempts to grow them on culture media failed, consequently little is known of their characteristics. They produce a thick coating of slime which contains a large amount of silica. There, of course, is a possibility

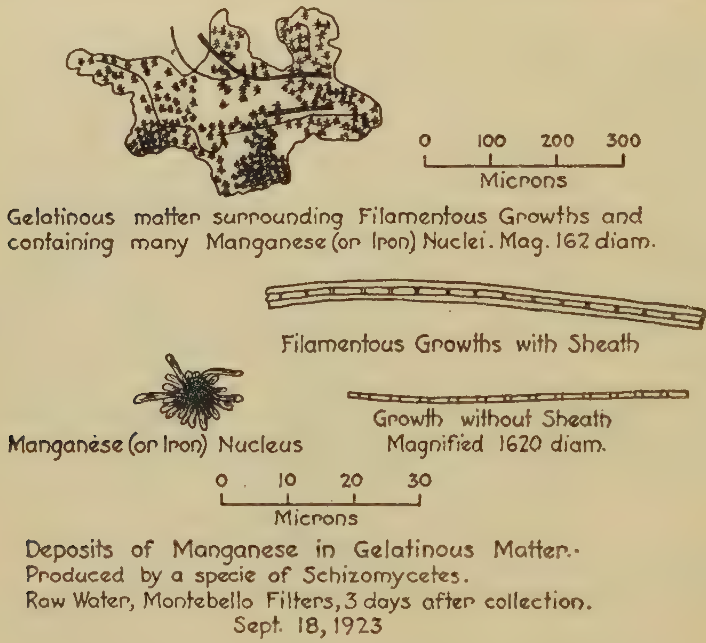


Fig. 5

that the precipitation of silica is due to other causes and the bacteria are incidental, however, all evidence indicates that the bacteria are the cause.

The biological growths precipitating manganese and iron includes a group of organisms that usually produce a gelatinous sheath or jelly masses, and probably of types that tend to break down organic acids. Any organism that will change or produce compounds that will change the composition of soluble compounds of manganese and iron may directly or indirectly cause precipitation. Harder (1) shows very

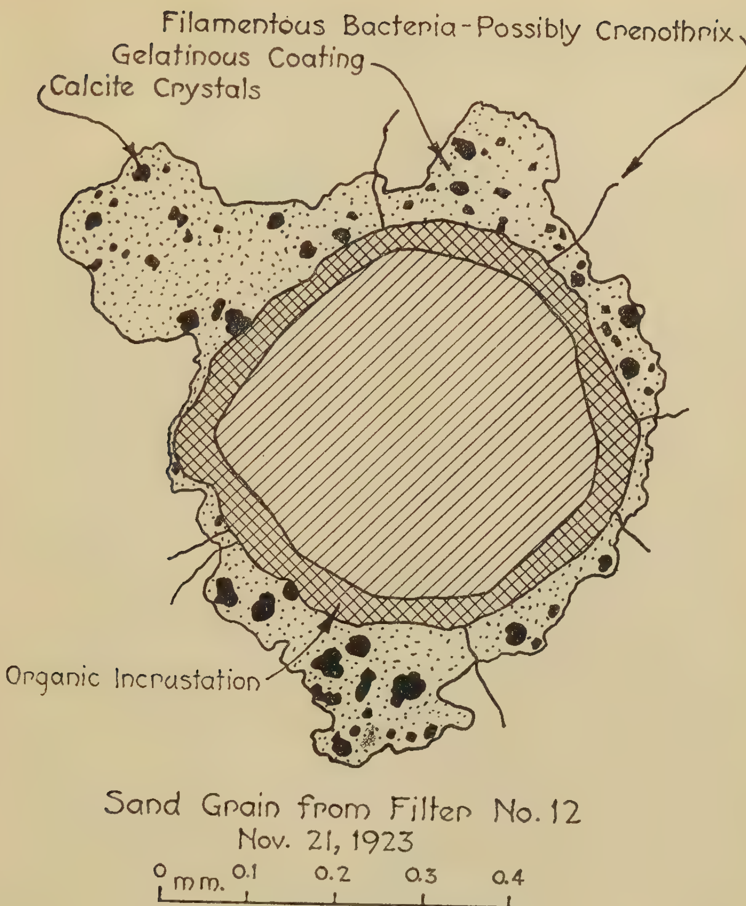


FIG. 6. BADLY COATED SAND GRAIN FROM NEAR THE SURFACE OF BED

During the summer of 1922 and 1923 all the grains had numerous filamentous bacteria (possibly crenothrix) growing from the organic incrustation. The gelatinous coating has been built up from a specie of slime producing bacteria, which started to grow on the grains in September, 1923. The bacteria are indicated by small dots. They are from 3 to 4 micra in diameter and are more numerous than shown. The gelatinous coating produced by these bacteria has overgrown and killed out most of the filamentous organisms, and have caused the filter beds to clog very badly. The use of iron and lime as a coagulant was started November 15, 1923. Numerous calcite crystals are observed in the gelatinous coating, which seems to form crystals more readily than the organic incrustation.

clearly there are species of bacteria that will precipitate certain iron compounds. He also shows that iron is not essential to the life of some of the so called "iron bacteria." The writer seriously doubts

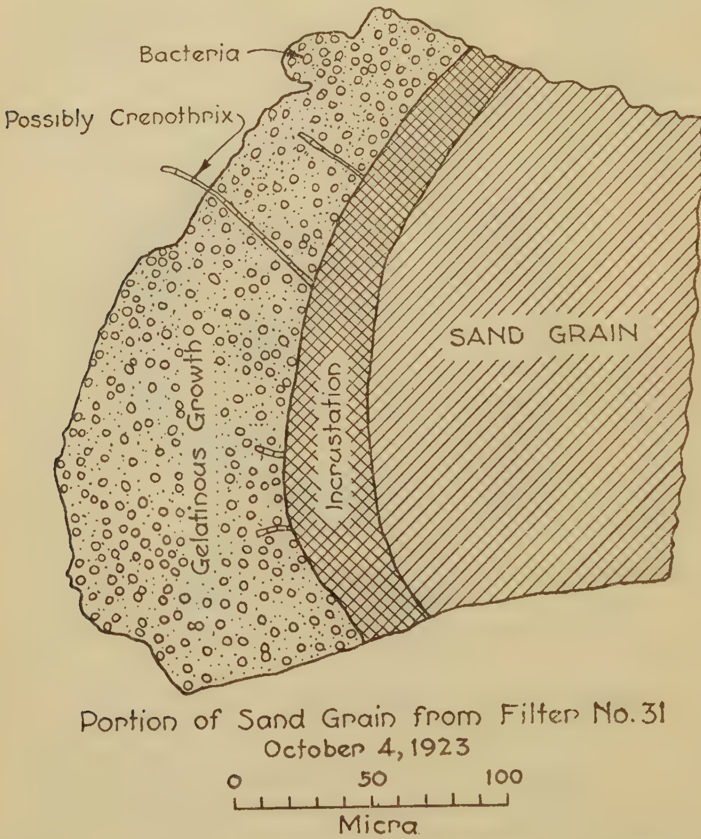


Fig. 7

Gelatinous coating started to grow on all the sand grains in all the beds about the first of September, 1923. A previous occurrence in 1922 started to grow about the first of August and lasted until November, being excessive during the months of August and September. The coating is produced by slime bacteria. Filamentous organisms, which were so numerous before growth started, have been reduced greatly.

the presence of iron or manganese being essential to the life of any organism. The fact that certain species of schizomycetes are usually associated with waters containing considerable iron is believed to be

due to the fact that they can live in the presence of these compounds, whereas other organisms can not. The presence of iron or manganese in water is very good evidence that it has contained considerable organic matter. It is believed the organic compounds serve as food for the organisms and not iron and manganese.

Extent of the manganese trouble. Manganese troubles may be divided into two general groups, staining and incrusting. The industries most affected were laundries. No one will tolerate manganese stains on white clothes. It is up to the laundries to prevent or remove the stains however costly. In our case the laundries were not aware of the presence of manganese until some time after they were having serious trouble. Each laundry thought the cause might be local, as there had never been previous trouble, and were cleaning and renewing water pipes in their plants. No one dared complain for fear it would reflect upon their business and cause loss of trade. Indignant customers were returning stained clothes, and in some instances changing laundries.

The fact that certain fabrics went through the laundrying process with practically no stains enabled us to form some conclusion as to the main essentials for staining. Greasy spots on towels, napkins, table covers, etc., stained first. Such fabrics are usually run through a bleach at the end of the washing process. White uniforms worn by nurses stained first around the neck and sleeves where the uniform came in contact with the body. Underclothes worn in direct contact with the body and not bleached, did not stain to a great extent. However, it seems that no fabrics were entirely immune. After the cause became known most laundries not using zeolite softeners, which ones we understand had very little trouble, were able to overcome the staining. They avoided the use of extremely caustic compounds, and many completed the wash in a slightly acid solution before bleaching. From the amount of oxalic acid sold it was probably used to the greatest extent, though some of the laundries used very successfully an acid compound used to set dyes. There was some staining of clothes washed at home, but the trouble was not so great as might have been expected. This was probably due to not using caustics and bleach to a very great extent.

The staining of white enameled water fixtures was greatest in the kitchen where grease came in contact with them, such as kitchen sinks. A few reported other articles stained, but it was not excessive.

Incrustation troubles, while not great at first, may become so later on. The report of almost complete stoppage of pipes at Pierre, S. D. (7), shows that it may become of great concern to the department in the near future unless the trouble is eliminated. It has increased our filter troubles by incrusting the sand grains and causing the filter beds to clog more readily. A reduction of manganese in the water after passing through the distribution system shows that the incrustation on the inside of the pipes is being built up. In reviewing briefly the reports of incrusting water pipes by manganese bearing waters, Corson (8) refers to articles by Weston (9), Raumer (10), Bailey (11), Jackson (12), Beythien (13), Vollmar (14) and Corson (15), which give a very complete record of troubles throughout the world. It seems evident from such reports that in practically every water supply where the manganese is present in quantities of 0.1 p.p.m. or over there is trouble from pipe incrustation.

Methods of removal. The large number of complaints from manganese staining, after it was known that this was the cause of the trouble, forced us to take active steps towards finding a method of removal. A review of available literature on manganese removal offered no great encouragement for immediate relief, for practically all previous attempts on a large scale has been by adsorption in filtering or percolating beds, frequently preceded by aeration. The fact that the adsorption process had been reversed by a biological action, not only in the reservoir and tunnel, but in the filter beds also, made it desirable to experiment along other lines for immediate relief.

Removal by precipitation with ferrous sulfate. Giessler (16) reports that by mixing the so called "Eichwald Water," containing 18 p.p.m. of Fe_2O_3 and 1.7 p.p.m. Mn_2O_3, with Herzog water containing 0.9 p.p.m. Fe_2O_3 and no manganese, in equal parts, removes iron to a trace and all manganese. Corson (8) found when equal parts of manganese as manganese sulfate and iron as ferrous ammonium sulfate were mixed and thoroughly aerated that all iron and practically no manganese was removed when filtered through clean sand. Dr. Arthur L. Browne, Penniman and Browne, Chemists, Baltimore, Md., suggested that ferrous sulfate might aid in the removal as the two elements had characteristics somewhat alike. The experience at the Posen Water Works as reported by Giessler also indicated that iron exerted some influence on the removal of manganese by precipitation. Consequently experiments were started with very encouraging results.

It is doubtful if any element occurring in quantities as low as 1 part per million or less can be successfully coagulated and precipitated without aid from some other precipitant. The conditions most suitable for precipitation may be the conditions under which it is precipitated easiest with another coagulant. Manganese is somewhat like iron in that the soluble compounds are usually converted into the insoluble hydroxide when the pH and alkalinity give points above the calcium carbonate equilibrium curve shown in figure 8. The manganese is much slower in action than iron and if quick results are desired the pH should give points considerably above the curve.

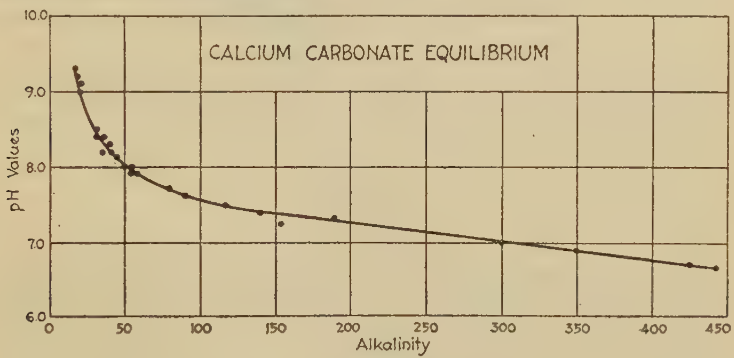


FIG. 8

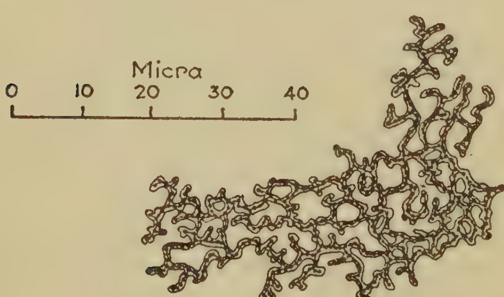
About 50 grams each of calcium carbonate from three different sources was pulverized in a mortar and placed into 300 cc. glass stoppered bottles. Distilled and Baltimore City tap waters were used. High alkalinity concentrations were obtained by passing carbon dioxide gas through the solution. The bottles were filled full of water, the glass stoppers inserted, and then allowed to stand in the laboratory for one week. C. P. calcium carbonate, pulverized limestone and surface crystals from a saturated solution of limewater were used. The water was changed several times before the first results were recorded. All 3 samples gave results alike.

The structural formations of ferric hydroxide and manganic hydroxide, as shown by figure 9, appear to be similar when observed with the high power microscope. It may be that the spherules of manganese and iron arrange themselves into "chains of beads," or fibers, composed of both the elements rather than each element tending to form separate chains or fibers. In fact the molecules of both may adhere in forming the spherules, which seems to be indicated by figure 10. Whatever the process of precipitation may be, practically all manganese was removed with the coagulant when the water was treated

Structural Formation of a Gelatinous Precipitate of Iron and Manganese Hydroxide
April 12, 1924
0 10 20 30 40
Micra

FIG. 9

About 100 parts per million of manganese sulfate and ferrous sulfate was made distinctly alkaline and allowed to stand one day. The solution was practically free from iron and manganese when filtered through paper. Most of the particles of floc were much larger and more compact than the above. This was selected to give a better idea of the structural formation.



Structural Formation of a Gelatinous Precipitate from a mixture of equal parts of Manganese Sulfate and Ferrous Sulfate treated with Sodium Hydroxide.

FIG. 10

with ferrous sulfate (shown in figure 11). There may be a certain ratio of precipitation between the two, which ratio is probably affected by the pH, alkalinity and other conditions. In the experiments conducted and in actual plant operation the iron was in considerable excess of the manganese. Ferrous sulfate was used as a coagulant in the plant from November 15 to October 2, 1923, and gave practically complete precipitation of the manganese. Filtering the coagulated water through paper gave complete removal, whereas with the alum coagulated water there was no reduction, showing that it was being removed with the iron. The mixing basin of the Montebello Filters is not designed for properly coagulating iron, and for this reason the cost of treatment was more than when alum is used. The fact that properly coagulated water with the use of iron and lime may be easily

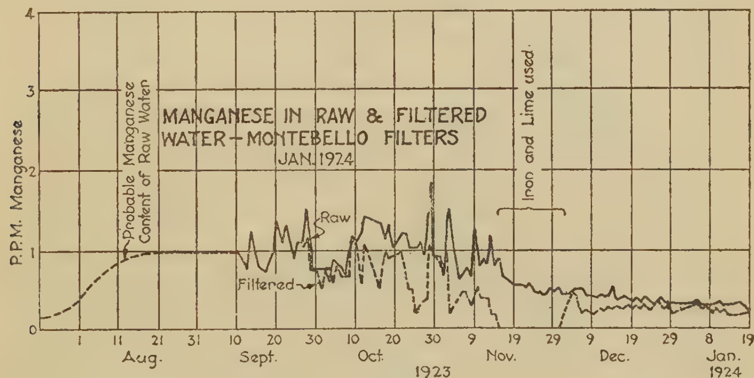


FIG. 11

obtained in the laboratory with much smaller amounts than are necessary for plant conditions shows that the trouble is in the mixing basin and not the coagulant. The structural formation of ferric hydroxide indicates that more is dependent on the proper physical forces to form a coagulation than is the case with some other coagulants, such as alum. When this is thoroughly understood it may be that iron can be successfully used for practically any character of water. Since the manganese is precipitated with the coagulant, it accomplished exactly what it desired. This will probably make it the most satisfactory method of removal where it is desirable to reduce it to a minimum. Laboratory experiments indicate that manganese sulfate is somewhat harder to remove than some of the other manganese compounds, but iron will still likely be the most efficient.

Removal by adsorption. Adsorption in filtering and percolating beds is usually a very cheap and in many instances a fairly efficient method. Removal by this method has been fairly well covered in

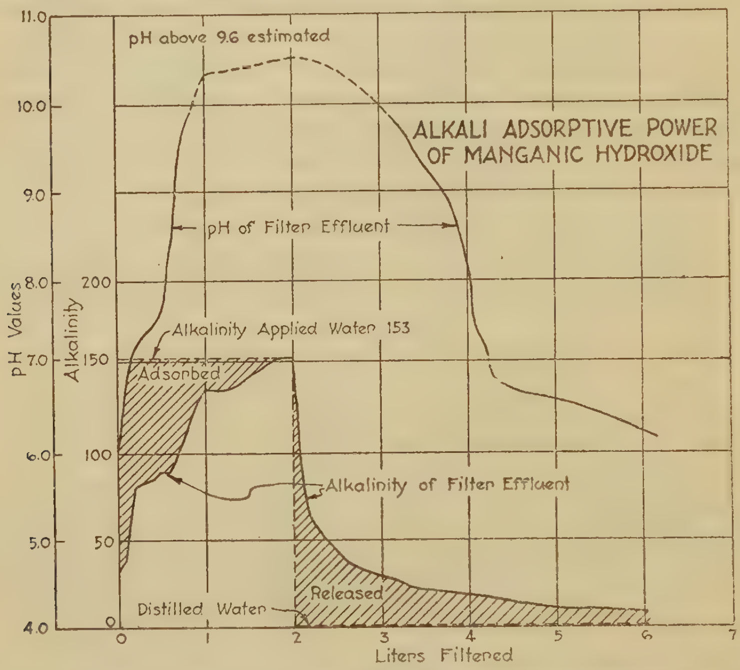


FIG. 12. VOLUME OF MANGANIC HYDROXIDE WHEN SATURATED WITH WATER ESTIMATED TO BE ABOUT 5 CC.

Clean silica sand was treated with manganese sulfate, potassium permanganate and sodium hydroxide until black coating was formed. Fifty-eight cubic centimeters of this sand, having an estimated volume of 5 cc. of manganic hydroxide, was placed in a laboratory filter and washed for several days by passing tap water through. After thoroughly washing with tap water, distilled water was passed through until there was no appreciable increase in alkalinity.

A solution of sodium carbonate was then filtered through at the rate of 2 gallons per square foot per minute.

After the alkalinity of the filtered water reached a point where it was the same as the applied water, distilled water was passed through at the same rate. Practically all absorbed alkali was recovered.

articles by Weston (17), Applebaum (18), Barbour (19) and Corson (8). The necessity of oxygen has led some to believe it is merely an oxidation process in which the soluble compounds are changed to the insoluble hydroxide. Corson believes that MnO_2 adsorbs the soluble

manganese, and gives up part of its oxygen to oxidise that adosorbed. Experiments confirm the fact that manganic hydroxide will adsorb the soluble manganese compounds, but the writer feels somewhat doubtful about the hydroxide being reduced to a compound of lower oxygen content. Reduction may take place under some conditions, but it is believed to be due to adsorbed acids.

Manganic hydroxide has remarkable adsorptive powers, which probably accounts for its power to remove the soluble compounds. Adsorption is defined by Falk (20) as being the difference in the composition of the surface layer at the contact of two phases and the composition of the main bodies of these phases. Figure 12 gives some idea of the alkali adsorptive power of manganic hydroxide. The curves indicate there is an equilibrium between the adsorbed alkali and the surrounding solution which depends on the alkalinity and pH. The adsorption or concentration of the alkali within the hydroxide rises rapidly as the pH increases. This is a very significant fact and may be the key to manganese removal by adsorption. The fact that it will adsorb the alkali from neutral salts such as sodium sulfate or chloride indicates that it has an affinity for certain, if not all, alkalies. By adsorbing both alkalies and the acid compounds of manganese, reactions are brought about that would not take place otherwise. The adsorptive powers of certain, if not all, gelatinous compounds, which are selective in their action, offers a vast field for future research. The commercial value of silica gel, a substance somewhat analogous to gelatinous compounds, is just beginning to be realized.

The activity of a surface, as explained by Langmuir (21), depends in general upon the nature of the arrangement and spacing of the atoms forming the surface layer. Hannan (22) gives an excellent presentation of microforces with reference to curvature and orientation, and calls attention to the fact that the water molecules adjoining a solid surface are oriented and for a stagnant layer. Without attempting to formulate a theory as to how the manganese is adsorbed, it seems well proven from experiments and the work of others that MnO_2, or higher oxides of manganese, have an attractive force for the soluble manganese. They seem to have the power of replacing or driving off the acid radicals. The curves in figure 12 indicate such a phenomenon when it seems that caustic alkali is apparently given off. Whatever be the nature of the reaction oxygen is required to complete the process; that is, to form the insoluble hydroxide. If oxygen is deficient the limit of adsorption may be the thickness of one, or a few molecules on the solid surface.

If sodium is adsorbed it will be exchanged for calcium somewhat similar to the action taking place in base exchange by the zeolites. There is no difficulty in producing water of zero hardness when sand from any of the filter beds is treated with sodium chloride, sulfate carbonate or hydroxide. The softening power lasts for only a short while unless the water is kept alkaline with sodium hydroxide or carbonate. Such a treatment probably could not be made to compete with the zeolites, but the fact that it has this power is interesting. Figure 13 shows how water may be softened when treated with sodium hydroxide and filtered through badly coated sand. This treatment

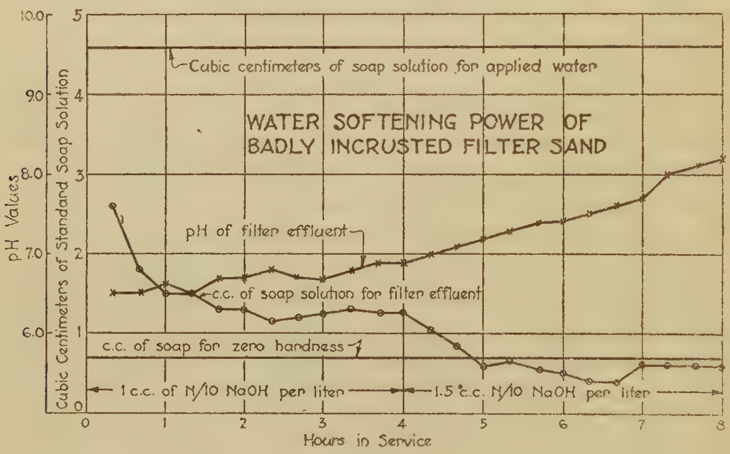


FIG. 13

Fourteen inches of sand from near the surface of Filter No. 19 placed in laboratory filter and water run through at the rate of 0.25-foot vertical drop per minute. Sodium hydroxide applied to laboratory tap water having a soap hardness of 54.3 p.p.m.

could not be continued indefinitely for the applied water must have a pH that will give points above the calcium carbonate equilibrium curve. Calcium carbonate will be deposited, and will probably stop up the pores in the hydroxide.

Manganese removal by adsorption in the filter beds. Removal by adsorption in the filter beds has not been very encouraging. Had there been no gelatinous coating around the sand grains, and had it been possible to aerate, better results may have been attained. As the dissolved oxygen was over 50 per cent saturation, except for a period of about 6 weeks, it is not believed that there would have been satisfactory removal by aeration under the conditions. Prechlorina-

tion probably would have prevented the bacterial growths, and with aeration may have given fairly satisfactory results. The sand in filter No. 21 was thoroughly washed with a Nichol's sand washing machine, and when put back into service chlorine at the rate of about 15 pounds per million gallons was added to the influent water. This was a very much higher dosage than could be used for the entire plant. The results were somewhat erratic at first and until the bed was drained dry for a few hours about once a week. After exposing to the air in this manner the manganese removal would be very good for five or six days, then there would be a gradual increase. The washing, and the high dosage of chlorine kept the sand grains fairly free from the slime coating. Yet with water containing from 6 to 8 p.p.m. of dissolved oxygen there would not be 50 per cent removal without occasionally draining the beds dry so as to expose to the air. No explanation can be offered as to why the aeration produced such a change in the adsorptive power of the beds, unless it allowed the adsorbed manganese to be changed to the hydroxide, which would give a free and increased surface area. The sand in the filter beds was being washed with a Nichol's sand washing machine at the time the manganese increased. Each bed was drained dry several days during the washing process. When thrown back into service there would be complete manganese removal and considerable reduction of alkalinity at first, then it would gradually increase until there was practically no reduction a week afterwards. The washing removed a great deal of the slime produced by the bacteria and allowed the sand to be exposed to the air for several days. Filter 25 was drained dry a few hours before washing each time washed. After a few days there was practically complete removal of manganese. The objections to such a procedure would be the necessity of about 50 per cent greater filtering area of the plant, and the enormous loss of sand with the foam when washing.

The addition of lime before filtration aided, but when alum is used as a coagulant the cost of treatment may be greatly increased. Experiments were conducted on a plant scale by adding lime to the water just before it goes to the filters. When enough lime was added to increase the pH above the calcium carbonate equilibrium curve fairly efficient reduction was obtained for a few days, but the sand grains soon became incrusted with lime and greatly reduced the adsorption. The incrustation around the sand grains obviates the necessity of accurate control of the application of lime in so far as it

pertains to the alkalinity and pH of the filtered water. If too much is applied for a few hours practically all the excess will be removed by adsorption, and if too little the incrustation gives up that adsorbed. With considerable hourly fluctuations of applied alkali the alkalinity and pH of the filter effluent will remain nearly constant.

Conclusions as to the most satisfactory methods of manganese removal. Manganese can be precipitated with ferric hydroxide in the iron and lime treatment. The fact that it is removed with the coagulant probably makes it the most satisfactory method. More study and the proper application of the physical forces will probably make iron and lime applicable to almost any water.

Most of the manganese may be removed by adsorption in filtering or percolating beds. Results confirm the previously published reports of others in that aeration, prechlorination, and the addition of an alkali before filtration increases the efficiency of this method.

The writer wishes to acknowledge the valuable suggestions and references to the literature on manganese given by Mr. Frank Hannan.

REFERENCES

(1) Harder, E. C.: Iron-depositing bacteria and their geologic relations. U. S. Geological Survey, Professional Paper 113, 1919.
(2) Marshall, Charles E.: Microbiology, 1911.
(3) Löhnis, F., and Fred, N. B.: Textbook of Agricultural Bacteriology, 1923.
(4) Moody, G. T.: The rusting of iron. Chemical Society Journal, vol. 89, page 720, 1906,
(5) Kindler: From Harder, U. S. Geological Survey, Professional Paper 113, page 47, 1919.
(6) Hawley, John B., and Mahlie, W. S.: Manganese deposit on water filters at Breckenridge, Texas. Engineering News-Record, vol. 90, No. 19, May 10, 1923.
(7) Sale, J. W.: Manganese in the water supply of Pierre, S. D. Engineering News-Record, vol. 79, no. 23, December 6, 1917.
(8) Corson, H. P.: Manganese in water supplies. Water Survey Series, N. 13, University of Illinois, October 2, 1916.
(9) Weston, R. S.: The purification of ground waters containing iron and manganese. Trans. Amer. Soc. C. E., 64, 112–81, 1909.
(10) Rauner, E. von: Ueber das auftreten von eisen und mangan in wasserleitungswasser. Z. anal. Chem., 42, 590–602, 1903.
(11) Bailey, E. H. S.: Occurrence in a deposit found in city water pipes. Jour. Amer. Chem. Soc., 26, 714–5, 1904.
(12) Jackson, D. D.: The precipitation of iron, manganese, and aluminum by bacterial action. Jour. Soc. Chem. Ind., 21, 681–4, 1902.

(13) Beythien, A., Hempel, H., and Kraft, L.: Beitrage zur Kenntnis des Vorkommens von Crenothrix polyspora in Brunnenwassern. Z. Nahr. Genussm., 7, 215–21, 1904.
(14) Vollmar, D.: Die Entmanganung des Grundwassers im Elbtale und die für Dresden ausegeführten Anlagen. J. Gasbel., 57, 1914.
(15) Corson, H. P.: Occurrence of manganese in the water supply and in an incrustation in the water mains at Mount Vernon, Ill. University of Ill. Bull., Water-Survey Series 10, 57-65, 1913.
(16) Giessler, E. A.: Experiments with a Jewell filter at the Posen Water Works. Engineering Record.
(17) Weston, R. S.: Some recent experiences in the deferrization and demanganization of water. Jour. New Eng. Water Works Assoc., no. 1, 1914.
(18) Applebaum, S. B.: Manganese in ground waters and its removal. Jour. Ind. Eng. Chem., February, 1916.
(19) Barbour, F. A.: Removal of carbonic acid, iron and manganese from the Lowell well-water supply.
(20) Falk, K. George: Catalytic Action, 1922.
(21) Langmuir, I.: From Falk, Catalytic Action, 1922.
(22) Hannan, Frank: Microforces: with reference more especially to orientation and curvature. Jour. Amer. Water Works Assoc., 10, no. 6, November, 1923.

OIL AND TASTES IN CHLORINATED WATER

Mr. W. R. Gelston:[4] For seven and one-half years, the water supply at Quincy, Illinois, had been sterilized with liquid chlorine with practically no complaints of tastes or odors which could be attributed to the chlorine treatment. The maximum average daily dose was 0.775 p.p.m. the maximum monthly average dose was 0.696 p.p.m.

In November, 1923, the chlorine absorbing capacity of the water seemed to be considerably reduced. The trouble lasted only a few days, but during that time there were many complaints, only one of which was of a serious nature.

A middle aged woman had become violently ill, one evening, a few minutes after drinking a glass of the water. She reported that she drank the water rather hastily and did not notice the disagreeable taste until she had drained the glass. She described the taste as being similar to iodoform. She called the attention of other members of the family to the unusual taste and they confirmed her statement. A doctor was called and the city water was duly found guilty of having caused the illness. The patient was

[4] Superintendent, Water Works Commission, Quincy, Ill.

confined to her bed for three or four days and seemed to be quite ill.

This trouble occurred at a time when the Mississippi River, the source of the supply, was at or near the low water mark. When the river gets below a stage of plus 1 foot, the 36 inch intake pipe in the main channel of the river, will not always deliver sufficient water. An additional supply is then secured through an old pipe which extends only a short distance into the river and which may, under certain conditions, deliver some water from Quincy Bay. Some water was being drawn through this old pipe when the trouble occurred.

Quincy Bay was formerly a part of the river and separated from the main channel only by islands. But government engineers closed the channels between the islands and converted a flowing stream into a two and one-half mile stretch of backwater from the river.

When the chlorine was causing trouble, an oily sheen was noted upon the surface of the water at the mouth of the bay and it appeared likely that phenol compounds were being drawn into the water supply through the old intake pipe.

Quincy Bay is used as a winter harbor for the storage of several steamboats and it was decided that the oil noted upon the water must have come from the steamboats. It was not until four months later that a better explanation for the source of the oil supply was found.

The daily papers reported the filing of a damage suit against the Electric Wheel Company by a farmer whose land was located upon the drainage area below the Electric Wheel Company plant. The papers filed in court by the farmer set forth that a concrete tank which was owned by the wheel company and used for the storage of fuel oil had developed a leak and permitted so much oil to escape into the creek that his livestock would not drink the water and that he was obliged to go to considerable expense to provide a new water supply.

Investigation of this clue revealed what was probably the real source of the oil which caused the trouble, if it was caused by oil.

On September 18, 1923, a carload of road oil was spread upon about one-half mile of unpaved streets in the vicinity of the Electric Wheel Company plant. This oil was purchased by the Wheel Company and some neighboring industries. The carload was more than was needed or desirable on the area treated; but it was all put on because it was necessary to get rid of it in some manner.

Heavy rains came just after the streets were oiled and most of the oil was washed down to Quincy Bay. The course it had to follow to reach the water works intake pipe consisted of about four miles of creek bed and about one and one-half miles of practically still water in Quincy Bay. After reaching the Bay it traveled very slowly and was probably still flowing out into the river in November when the trouble occurred.

This paper is submitted merely as an interesting experience. The doctor who found the water guilty of causing the woman's illness is inclined to condemn the water supply on very meagre circumstantial evidence and the cause of the illness is probably still a debatable question. If the trouble with odors and tastes in the water was due to the reaction of phenol products with the chlorine, the source of the phenol products is still a debatable question. If such products are contained in road oils, other water works men may find in this paper an explanation for similar troubles which they have experienced.

In conclusion the attention of the chemists should be directed to the real need for a simple indicator of the presence of phenol compounds in waters which are to be treated with liquid chlorine.

CAUSTIC SODA AND SODA ASH SOLUTIONS FOR FILTER SAND WASH

Mr. Frank W. Green:[5] A most important part of the operation of a rapid sand filtration plant is the keeping of the sand in proper condition to secure efficient filtration.

The introduction of chlorination into water purification has caused many places to increase the rate of filtration, thereby throwing a greater burden upon the washing devices. The beds become dirty in a shorter period of time than was formerly the case, so that the periodic removal of these accumulations has become of considerable importance.

Attention has also been given to improvements in the day by day washing methods, but in many cases no changes in this direction have been made. At Little Falls we have increased the velocity of the wash water somewhat, and have doubled the number of strainers along the sides and at the corners of the filters. This is not entirely effective, and in time the sand grains become coated with a greasy

[5] Superintendent, Filtration and Pumping, Montclair Water Company, Little Falls, New Jersey.

coating of organic matter which reduces the effectiveness of the sand bed.

The replacement of the old filtering material with new sand and gravel is too long and expensive a procedure to be considered if the material can be cleaned in place. Strong acids and also alkalies will remove the coating, but the use of the former is prohibited by the fact that they would attack the metal portions of the underdrains and strainer heads. Soda ash has been used for many years with but indifferent success.

Experiments in our laboratories showed that caustic soda would attack the coating, and that a mixture of not over three parts of soda ash to one part of caustic soda was also effective. In order to determine the proper amount of solution to use in a bed, the filter was washed, the surface coating of mud scraped off and several weighed portions of an average sample of the sand boiled with varying amounts of the mixed soda solution.

Our filter beds contain forty tons of filter sand and twelve tons of gravel. In most cases the application of 350 pounds of caustic soda and 1000 pounds of soda ash gave satisfactory results. In a few beds that were particularly dirty a slightly larger amount of the chemicals were used. The caustic soda and the soda ash were dissolved in separate tanks, and the solutions applied to the bed so that the liquid covered the surface of the sand to the depth of about an inch. The tank was then heated by means of live steam to just below the boiling point for a period of two days. After washing, the sand was as clean and sharp as when new; the organic material and any aluminum hydrate that may have been present had been entirely removed.

Other plants handling a colored water have reported equal success with this method.

RECONSTRUCTED SETTLING BASIN IMPROVES EFFICIENCY

Mr. C. R. Henderson:[6] The most interesting experience I have had in water treatment recently has been the building last fall of a division wall and weir in the settling basin at Davenport. This basin is irregular in plan, more or less rectangular, and holds 4 million gallons of water at a depth of about 12 feet.

[6] Manager, Davenport Water Company, Davenport, Iowa.

Currents existed between the inlet and the outlet and the basin could not be cleaned except when the condition of the raw water was favorable to filtration without prior sedimentation.

The new wall divided the basin into two nearly equal compartments, permitted cleaning of either compartment at any time and provided a perfect weir between the two compartments, each compartment holding about 2 million gallons. The quantity treated equals 5 million gallons per day. Before the division wall was built the average quantity of alumina used in November for thirteen years was 2.72 grains per gallon. The average for December was 2.30 g.p.g., for January 2.23 g.p.g., February 2.80 and March 3.72 g.p.g. Since building the wall, we have used in November 1.59 grain, December 1.49, January 1.24, February 1.68 and March 2.57 grains per gallon.

The raw or untreated water may vary more or less and there is always a chance that close watching may result in less coagulant being used over a short period, but it is our opinion hat average conditions have prevailed, that the quantity of coagulant used has been sufficient and that the effluent of the settling basin has been of rather higher quality since the wall has been used than it was before.

The saving has been 1 grain per gallon in 5 million gallons per day and amounts to 715 pounds alumina per day (worth say $8.00), or nearly $3000.00 per annum.

The cost of the division wall and weir was $7700.00

SOME RECENT ADVANCES IN PURIFICATION AUXILIARIES

Mr. Charles P. Hoover:[7] I did not understand that I was to talk on any one particular subject as indicated by the Chairman, but that I was to tell about any interesting things of a water works nature that I have seen since the first of the year. I shall therefore tell you very briefly of some half dozen things that have interested me during the past year.

On my way to this Convention I stopped at South Pittsburgh and saw the most interesting softening plant I have ever seen any place. I am sure that the members of this section would be glad to have Mr. Trowbridge, Supervising Chemist of the plant tell us at our

[7] Chemist, Filtration Plant, Columbus, Ohio.

next meeting about the interesting chemical problems involved in the treatment of the South Pittsburgh water supply.

The plant belongs to the American Water and Electric Company and it is built in a deep ravine. The adaptation of the different units to the conditions there is really remarkable and if I had occasion to build a large water softening plant I think I should want to find a ravine to build it in.

I went from the plant to the laboratory and Mr. Roy Welter, the chemist in charge of the plant showed me a little laboratory agitator used in experimental work for mixing chemicals with water and the unique feature of it to me was that the driving mechanism was made out of the gears of an old water meter. This made its cost practically nothing and at the same time provides a device the speed of which can be accurately controlled.

This winter I visited the new Sacramento filtration plant designed by Mr. Charles Gilman Hyde and it is one of the really good looking plants in the country. The plant is provided with mechanical agitators which interested me very much and these agitators are driven by water engines. Water taken from a force main passed through the water engines driving the agitator mechanism and discharges from the engines into the wash water tank. It requires just about as much water to drive the mechanical agitators as is needed to wash the filters and therefore the cost of driving the agitators is reduced to a minimum.

I recently saw water pumped from a well at Miami Florida which had a color of 100 parts per million which I think is unusual.

The chairman has asked me to tell about the operation of the Dorr Clarifier which was installed at the water softening and purification plant at Newark, Ohio.

The Newark plant is built on a small river above the city and it was felt that the large amount of sludge resulting from the water softening-reactions, if retained in settling basins and discharged intermittently into the river, would create an unsightly condition. Therefore, a Dorr clarifier was installed in order to be able to discharge the sludge into the river continuously. The results of operation show that 95.4 per cent of the suspended solids are removed in the Dorr clarifier and that the discharge into the river is not noticeable. Other advantages of the clarifier are:

The period of retention in the settling basins is not being diminished each succeeding day by the accumulation of sludge. In other

words, the full capacity of the settling basins is available for sedimentation purposes instead of being storage reservoirs for sludge. It is possible to build this type of tank below the level of drains, that is if the sludge is pumped.

Carbonation. The presence of normal carbonates in lime softened water or rather the deposition of the carbonates on the filter sand, in the distribution system, meters and hot water lines, has been the principal objection to municipal water softening. Investigation toward working out a practical method of eliminating these difficulties were started at the Columbus Water Softening plant about five years ago and the first results of the experiments were published in the 1920, Annual Report of the Division of Water, Columbus, Ohio.

The first successful plant, that we know about, for carbonating a municipal water supply was built at the municipal water softening plant at Defiance, Ohio, in 1920 by Mr. Nicholas Hill (This JOURNAL, vol. 2, no. 2, March 1924).

The Newark, Ohio carbonation plant consists of a steam driven reciprocating, gas compressor, taking its suction through a dryer and scrubber from the breeching of the boilers and forces the scrubbed and dried gas through diffusers located in the settling basins near the outlet.

The operation of the plant indicates the water can be successfully carbonated by means of the flue gas, but there is one difficulty that must be overcome before the process can be regarded as entirely satisfactory. The hydrocarbons condense, forming tar-like deposits in the valves and heading of the air compressor. We hope to have this difficulty overcome in the near future.

PRECHLORINATION AT TORONTO

MR. N. J. HOWARD:[8] I should like to tell you briefly about our modified system of chlorine and alum treatment at Toronto during the past year. You will doubtless remember some two years ago, a paper which I presented upon a pre-chlorination process which we adopted in 1921. In order that your may better appreciate my remarks, it is necessary to describe again, as briefly as possible, the conditions under which the modified chemical system was first adopted, and the further modification which we made last year and which was used successfully throughout the year. The water at

[8] Bacteriologist in Charge, Filtration Plant Laboratory, Toronto, Ontario.

Toronto is derived from Lake Ontario, and is physically good for at least two-thirds of the days during the year. At other times, although not bad, it has a turbidity of 50 to 200 parts per million, and, as in many other cities, the degree of turbidity is naturally controlled by the meteorological conditions. The conditions we have to contend with is the period of turbidity, particularly in view of the fact that we have no sedimentation basins. Alum is added to the water which passes directly on to the filter, the whole process taking approximately twenty-eight minutes. We find, particularly in the summer months, that the water is subject to excessive pollution, the degree of which varies enormously and is controlled by the prevailing meteorological conditions. Sometimes in the morning, the laboratory figures, as judged by the free ammonia test, show the water to be chemically pure. The normal free ammonia content would be 0.002 part per million. Quite often, owing to inevitable conditions, this figure would rise in the afternoon to 0.20 part per million and show a heavy bacterial pollution. Now in order to treat this water, particularly in warm weather, it was necessary to apply big quantities of alumina—big quantities to us, but comparatively small to many other cities. The amount applied was $2\frac{1}{2}$ grains per imperial gallon of alumina sulphate and at this time we were filtering between 40 and 50 imperial gallons per day. During the summer months, with the plant working up to capacity at a rate of 150 million gallons per acre per day, the addition of alum in that quantity placed a heavy load on the plant besides being extremely costly. We carried out experimental work, and found that we could eliminate alum at such times as the water was physically good, and substitute chlorine, which was applied immediately before filtration. As the plant is situated on the island and receives further chlorine treatment on the mainland, no attempt was made to sterilise the water. We put in an initial amount of chlorine so as to give a satisfactory purification and leave no residual chlorine in the filtered water, thus making the water suitable for final treatment on the city side, By doing this a saving of $35,000 was effected in operating costs.

In 1922 we found by practical experiment that the water could be successfully treated by using a smaller amount of alum with a modified system of treatment. When turbidity in the raw water ranged between 10 and 200 parts, we were able to reduce the quantity of alum, provided chlorine was applied at the same time, sufficient alum being added to clarify completely the water. Experiments

showed that, when chlorine was added in combination with alum, it was possible generally speaking to reduce the dose of alum to half a grain per gallon, and get a water physically and bacteriologically satisfactory. This has been the practice during the past year, using chlorine alone when the water was physically good, and chlorine and alum when the conditions made it necessary. Covering a period of three years we reduced the operating costs $148,000 and have been able to get the maximum quantity of water through the plant. We produced a physically good water, and bacteriologically better than when alum alone was being used. We have not advocated this method of operation elsewhere, and consider it is a question which has to be worked out locally, the whole situation depending entirely upon the quality of the particular water and system of purification involved.

At Cleveland, results indicated that this treatment of chlorine alone and the chlorine-alum combination did not work out. We feel, however, that our particular system of filtration which involves the drifting sand process is particularly suitable to this modified process. We have ten feet of sand in our filters, and due to the peculiar drifting sand system in which a portion of the sand is continually moving, we always have a minimum permanent layer of stationary sand of not less than 27 inches in depth. It is somewhat difficult to explain without seeing the plant which is decidedly complicated. Mr. Weston has successfully tried the chlorine-alum treatment with colored waters and has been able to reduce the color to some extent. So with waters of moderate turbidity and color, it seems a logical way to treat water, in order to secure a reduction in operating costs and at the same time get water acceptable from a sanitary standpoint.

SODA ASH FOR PREVENTING CORROSION AT CAMBRIDGE, MASS.

Mr. M. C. Whipple:[9] I shall say a few words about one of the problems of the Cambridge, Mass., plant. This plant was put into operation a year ago. It is one of the rapid sand type, equipped with coagulation basin and apparatus for the addition of alum and soda. After the plant had been in operation for a few weeks it became apparent that the most important subject for immediate study would

[9] Instructor in Sanitary Chemistry, Harvard University, Cambridge, Mass.

be the corrosive quality of the effluent. The raw water is typical of New England, having a color of 30 to 60 parts per million and an alkalinity of 10 to 20 parts.

During the first few weeks of operation we were troubled with iron deposits under cold water taps and greenish deposits under hot water taps where brass was used. The hydrogen ion concentration of the treated water was in the vicinity of pH 6.1 or 6.2, the carbon dioxide content 7 or 8 parts per million, and the alkalinity 5 parts.

In order to correct this condition it was not possible with the facilities at hand to add soda to the effluent water. If added to the raw water in necessary amounts to combat corrosion, coagulation was interfered with. Changes were made to allow the addition of soda to the filtered, aerated water as well as to the raw water.

With addition of soda to the effluent during the past four or five months a hydrogen ion concentration of pH 6.6 to 6.9 has been maintained. The carbon dioxide content has been reduced to about 4 parts per million and the alkalinity increased to 15 to 20 parts. The quantity of soda used has varied between 80 and 140 pounds per million gallons. This has increased the cost of purification, on the basis of $1.70 per hundred for soda, by $1.30 to $2.30 per million gallons.

This seems, perhaps, a rather expensive method of combating corrosion. There are cheaper means of increasing alkalinity and reducing hydrogen ion concentration, lime treatment for instance, but we have used soda for several reasons. One is that the plant was equipped with apparatus for doing this. Another is that the hardness of Cambridge water is somewhat greater than that of other surface water supplies in that region, being 30 parts per million. It is looked upon as moderately hard. To use lime to combine with CO_2 and reduce hydrogen ion concentration would result in an increase of about 30 per cent in the hardness. This would be liable to bring forth complaint from the average consumer.

Another factor which led to continued use of soda was the experience with boilers. After the plant had been running about three months without soda treatment to the effluent observations upon the boilers at the pumping station led to the discovery that a very hard, compact crystalline scale was being formed in the tubes. This had a high degree of resistance to passage of heat and was unlike the soft, laminated scale formed with the raw water. The old scale was largely calcium carbonate, the new nearly pure calcium sulphate. It was

evident that the change would bring about boiler troubles that did not previously exist in the community. The difference in the character of the scale was due to the fact that alum treatment, without addition of soda, increased the sulphate or permanent hardness of the water about 100 per cent, from about 12 parts per million to 24 or 25 parts. On a percentage basis this represents a radical change in character from the standpoint of boiler operation. In using soda in necessary amounts to combat corrosion most of the increase in sulphate hardness was prevented.

I have kept close watch of corrosion in the city, and have developed a rough and ready test which measures increased corrosive quality and checks up the uniformity of treatment at the plant. At my house a cold water tap over a porcelain bowl has leaked consistently for several months at the rate of a drop a second. When the hydrogen ion value at the plant dropped below pH 6.7 or 6.6 for any length of time a distinct iron stain would appear on the bowl in twenty-four hours. No stain was apparent in the same length of time with a pH value of 6.8 or higher. Record was kept from day to day of the intensity of this stain and the observations compared with the plant record of hydrogen ion value. There was a high degree of correlation between them.

In cold weather it was found that a pH value of 6.8 to 7.0 held corrosion within very satisfactory limits. With rising temperature of the water in summer it is already evident that corrosion will increase and that it will be necessary to make the water more alkaline. This will not involve the addition of more soda (probably less will be used) for the raw water carries less CO_2 and has a higher pH value during the months when algae are growing.

Any relapse in addition of sufficient soda to the effluent of the plant has always been followed in the city by increased corrosion. This is noticeable in formation of stains and in the color of the water which has stood in contact with the pipes for several hours.

WATER-SOFTENING IN VIRGINIA BY IRON SULPHATE AND LIME

Mr. L. H. Enslow:[10] At this time I should like to say something about a matter which I have not gotten very far with but hope to report on more fully at a later date. It is relative to water-softening.

[10] Assistant Sanitary Engineer, State Department of Health, Richmond, Virginia.

Water-softening is now a live subject in certain parts of Virginia as it should be everywhere where people have to use a hard water. With filtration progress we have done pretty well and now we have to push along softening also for certain sections. Heretofore we were very well satisfied when people did not have to drink bacteria or mud, but now there is a demand for softened water also and we are only too glad to help in the matter.

In the process of softening it would appear that the use of iron-sulfate is of considerable advantage or rather I should say it is with at least three or four different waters on which it has been tried.

In order to obtain information as to the best control of the softening process to be adopted at a new plant in Virginia I started a one man study, taking along my little field grip filled with chemical solutions and with the aid of a few Mason jars set up the laboratory.

Through the experimental work I established the fact that iron-sulfate solution has definite merits in softening. Having worked out the most satisfactory quantity of lime to apply when used alone and obtain the maximum economical softening with the least "after precipitation" or incrusting properties, I tried the effect of using a constant dose of iron and varying the lime.

Before the iron was tried knowledge of the use of alum as an agent to hasten the formation of the precipitate in softening led me to experiment with alum. It was found essential that not less than 1 grain be used. The results were satisfactory and a much quicker and larger grained precipitate—than from lime alone—could be had. The discouraging feature lay in the fact that when the filter effluent was tested for the presence of alum it was found that all except $\frac{1}{4}$ grain was in the filtered water. That is $\frac{3}{4}$ grain was passing the filter. This did not look encouraging from an economical point of view, even assuming that the folks did not object to drinking the $\frac{3}{4}$ grain. The next best bet sounded like iron-sulfate and from the experiments the use of it was apparently as satisfactory as alum and at the same time it was found that only $\frac{1}{2}$ of a grain was required to accomplish equally, if not better, results than was had from the alum.

The one important thing to be remembered in the application of iron is that it must be added just ahead of the lime and *not after it.* It does not appear that more than a half minute or so is necessary but it is essential that the mixing is quick and fairly thorough for the best results. In a gravity plant the iron may be applied at the inlet to the mixing chamber or just ahead of it and the lime held until the second

or third bay of the chamber. In plants with low lift pumps naturally it will enter at the suction side of pumps.

From my experience both in the Mason jars and in the plant I can tell you now that when $\frac{1}{2}$ grain of ferrous sulfate is added to the water just prior to the lime a much superior precipitate is more quickly formed. It is more crystalline in appearance, settles very much more readily, leaves a much clearer sparkling water above. What little suspended precipitate goes into the filter does not choke it as rapidly as the water treated with lime only nor does it give the same incrustation either on the sand grains or in the mains, meters, etc., thereafter. I have data, figures and curves here to prove these statements but they are not now in shape for presentation. I hope later to say more about this feature of water softening and at that time will have more plant data to work on, since at present there are only two plants that have adopted it, but others will do so shortly.

What the exact rôle played by the iron or alum is I am not able to explain on a scientific basis. The precipitate when using iron does not appear under the microscope to possess any different crystal form from that of lime only. It was at first thought that the effect might be similar to that obtained through precipitating calcium in hot solutions by adding lime. In the latter case it is understood that the carbonate is formed as aragonite instead of calcite, as is the case in cold solutions. The only physical difference in the two precipitates noted is that where iron was used it is very nonuniform in particle sizes as compared with the uniformity of the straight lime precipitate. Contrary to expectation the iron is not uniformly distributed, but rather appears concentrated in widely separated crystals which are larger than the rest.

Samples of the filtered water representing the same dose of iron, but the lime varied over a considerable range, and a second set in which the lime dosages were the same but no iron was being added at the time of sampling were collected in large glass bottles and held for observation as to after precipitation, that is the property of incrustation and pipe coating. Those samples treated with lime only showed a very narrow range of treatment which could be called satisfactory and in every case the effluent was somewhat an incrusting one in the cold. The same was not true of those which had been iron-treated and the range of lime dosage which could be called satisfactory was appreciable.

From the results, therefore, it appears entirely practicable to utilize whatever extent or degree of softening that would appear to meet the particular requirements for a given supply and depend upon the iron to perform the functions which I have outlined.

In one particular installation the iron is invaluable. The supply is from a stream a short distance below the out-crop of several limestone springs. Normally the water is very hard and clear. Only sufficient lime is added to produce an effluent of 100 parts alkalinity-hardness. After heavy rains considerable turbidity appears and the hardness drops to less than 100 in the raw-water. At such times the iron dosage is raised to about two and at times as much as three grains per gallon and the lime reduced to obtain a normal carbonate alkalinity of but 20 to 30 parts. During such practice the plant is useful for turbidity removal primarily and the softening is a side issue. Prior to the advent of the iron treatment the plant could not handle the turbid water and produce a clear effluent and during the normal condition of the stream an optimum lime dosage had been essential to obtain a satisfactory precipitation in the basins.

It appears that the feature of greatest interest to the engineer when considering the value of iron-sulfate in softening is that its use will apparently allow for a smaller precipitation or coagulation basin or in other words by reducing the time to obtain the results which have required the relatively large basins and long period which in the past have been deemed necessary for the completion of reactions and precipitation.

It would appear that the mixing chamber or tank is by far the most important unit in the softening plant. Providing for the best obtainable mixing device and velocity through it will leave but comparatively little for the lime, the iron and the operator to worry about.

IRON REMOVAL PLANT AT GRIFFIN, GEORGIA

MR. E. S. CHASE:[11] An interesting treatment plant for the removal of iron from deep well waters was put into operation at a cotton bleachery in Griffin, Georgia in the spring of 1923. Prior to the design of the plant small-scale experiments were carried out and upon the results of these experiments the design of the plant was based in large measure.

[11] Sanitary Engineer, Metcalf & Eddy, Boston, Mass.

In the bleaching of white cotton goods it is very essential that the water supply used for washing be practically free from color and iron. The available water supply for the bleachery is from a series of deep wells containing iron in variable quantity. The experiments indicated that aeration, pre-filtration through coke and rapid sand filtration without the use of coagulant gave satisfactory results.

On the basis of the experimental evidence, a million gallon per day plant was designed, consisting of 2 units of coke pre-filters upon which the raw water was applied by spray nozzles, 2 units of settling basins and 4 units of rapid sand filters. The coke filters are contained in concrete tanks 9 feet by 33 feet by 9 feet superimposed over the preliminary settling basins. The filter media is 6 feet deep and consists of broken coke about 1 to 2 inches in size. In each unit there are 33 nozzles attached to lateral lines of distributing pipe. These nozzles are of brass and are similar to the sprinkler head of an ordinary garden watering can.

Each nozzle contains 21 holes, $\frac{5}{32}$ inch in diameter. The sprays, when the plant is in operation, rise about 2 feet in the air. The water falling and splashing over the surface of the coke becomes aerated to about 90 to 100 per cent saturation. Precipitation of the iron occurs on the surface of the coke medium and opportunity for deposition of iron sediment which may wash out from time to time from the coke is afforded by the settling basins.

These basins are each 9 feet 0 inch by 40 feet 0 inch by 8 feet 6 inches (water depth) inside dimensions with a capacity of 23,000 gallons, equivalent to approximately 1 hour storage with the plant operating at capacity. From the settling basins, the water flows to the rapid sand filters which are of the ordinary type. The filter media consists of 2.5 feet of fine sand with an effective size of 0.3 to 0.4 mm. and a uniformity coefficient of about 1.60. Under the sand is a 1.5 foot layer of graded gravel. The collecting system consists of a grid of wrought iron pipe. Rate controllers and loss of head curves are provided. Wash water is supplied at a rate of 24-inch. vertical rise per minute from a small elevated tank having a capacity of 18,000 gallons and 35-foot head to floor of filters. The nominal rate of filtration is 100 million gallons per acre per day.

The results obtained with the operation of the plant have substantiated the experimental evidence. The iron content of the raw water ranges from 0.2 to 2 p.p.m. which is reduced by the treatment plant to about a trace to 0.2 p.p.m.; the carbon dioxide content of the

raw water ranges from 10 to 30 p.p.m. and is reduced to about 2. p.p.m., thereby materially diminishing the corrosive qualities of the supply. The final effluent is clear and colorless and is giving entirely satisfactory results in the bleaching process. One man has charge of the operation of the plant and of the deep well pumps. The chemist of the bleachery makes frequent analyses of raw water and of the final effluent.

CHROMOGENIC ORGANISMS IN SWIMMING POOLS

Mr. T. D. L. Coffin:[12] At Bedford Hills, New York, there is a privately owned swimming pool some 60 feet in length and 20 feet in width which is supplied with spring water in volume sufficient to change the water in the pool about once in four days. This spring water is free from turbidity, color or iron, and in other respects is normal for the region. However, the owner of the pool has never found it satisfactory, for each season about ten days after filling the pool in early July, a decidedly red color develops in the water, and after a few days a brownish-red sediment appears upon the steps and pool bottom, the water retaining its reddish hue. This discoloration continues through out the summer, the pool being emptied usually in mid-September.

Some years ago, upon the advice of another, the owner treated the pool with copper sulfate in the usual manner without result, and last year called this case to the writer's attention. Samples of the water were taken to Mr. Luther R. Sawin of the Mt. Kisco Laboratory, who determined that the color was the result of the presence of Trachelomonas, an organism having a particularly resistant lorica, and one which is free from chlorophyll.

In the laboratory, samples of the water were treated with various strengths of copper sulphate up to a dose of 15 p.p.m. without results after an hour's standing in contact with the chemical. Samples were also treated with varying strengths of chlorine derived from chloride of lime and it was found that 50 p.p.m. of chlorine would remove the color from the water.

Later, in a small garden pool receiving the overflow from the swimming pool, the waters of which also have this reddish color, a practical test of the efficacy of chlorine was made and the laboratory find-

[12] Assistant Engineer, Bureau of Water Supply, New York City, Katonah, N. Y.

ing there was confirmed, although, as a bleaching powder itself was used, there was a milkiness in the water resulting from the lime present. The reddish tinge disappeared absolutely.

It is not known that this organism has ever been present in a potable water supply in sufficient numbers to occasion a reddish cast to the water, but the possibility exists, and it would appear that the remedy for its eradication must be other than the usual copper sulphate treatment and that the amount of chlorine required would make that method prohibitive for reasons other than cost alone.

Mr. G. R. Taylor:[13] Dr. Buswells' remarks recall an experience of the writer with a small private swimming pool. The pool was enclosed but had a glass roof which gave full sunlight on the pool. Salt was added in such quantities as to make the salt content considerably greater than sea water. This pool became infected with an algal growth which gave the water a brilliant green color. Copper sulphate in ordinary amounts failed to kill the growth, but it was finally removed by the dose of 100 parts to one million parts of water. A little later the artesian well supplying the family with water developed a peculiar sweetish taste, as they described it. Analysis showed the presence of chloride in large quantities indicating that salt water from the pool was reaching the well. It was the practice to flush the pool daily into the overflow drain which ran past the well at a distance of about 75 feet. Suspicion pointed to this drain, so a bag of salt was placed in the drain and water flushed through it. Within two hours the water in the well was too salty to drink. Investigation showed a break in the overflow pipe at a point about 100 feet from the well. As the well was over 300 feet deep with a considerable portion through rock there must have been a fissure leading directly through to the well.

[13] Chemist, The Scranton Gas and Water Co., Scranton, Pa.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Purification of Boiler Feed Water and Circulation Water. B. Alexandre. Chaleur et Industrie, Dec. 1922: Water and Water Eng., 25: 224, 1923. General paper, detailing among other processes, the recent German one by Balcke, termed "vaccination."—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Correctly Designed Swimming Pool. G. L. Lockhart. National School Building Journal, 5: 16, 1924. Constructional features and purification equipment for installation. 20 x 60 feet.—*Jack J. Hinman, Jr.*

The Feeding of Some Plankton Organisms. Dr. Marie Labour. Water and Water Eng., 25: 375–6, 1923. Jelly fish and the ctenophore, *Pleurobrachia pileus*, were observed to eat newly hatched fish.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Comparison between British and American Water Works Practice. George Mitchell. Water and Water Eng., 25: 462, (1923). Condensed and valuable comparison; especially remarkable, as author states he has no personal experience with American conditions.—*Jack J. Hinman, Jr.*

Geology of the Catskill Scheme, New York. H. J. F. Gourley. Water and Water Eng., 25: 443–449, (1923). A descriptive paper based largely on that by Berkey and Sanborn, entitled The Engineering Geology of the Catskill Scheme. *Cf.* this Journal, 10: 2, 328; 6, 1128.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Lessons of the War Water Supplies.—A. Sarmiento. Memoria de Ingenieros del Ejercito, May, 1923; Water and Water Eng., 25:3 92, 1923. Review of water supply work of German, French, American, and British armies.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Table in the Coastal Regions of Flanders. Dewevre. L'Eau, March, 1923; Water and Water Eng., 25: 226, 1923. Water found at varying depths in greensand is very high in Cl and unfit for drinking. Use made of wells which do not pierce clay stratum and hence supply the filtered water of the sand dunes.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The How and Why of Safety Valves. R. J. S. Pigott, G. S. Coffin and Editor. Power, 58: 10, 357, September 4, 1923. General principles that underlie operation of the different types of valves are described, and probable causes of leakage discussed. Illustrations given of typical safety valves, with brief descriptions—*Aug. G. Nolte.*

The Operation of Hydro-Electric Stations. Ralph Brown. Power, 58: 10, 363, September 4, 1923. How to obtain maximum output with minimum consumption of water from equipment available.—*Aug. G. Nolte.*

An Oil-Engine-Driven Ice Plant. Power, 58: 10, 375, September 4, 1923. The construction and operation of the 50-ton Plant of the Red Bank, N. J., Pure Ice Manufacturing Co., is described.—*Aug. G. Nolte.*

Accurate Methods of Aligning Steam Turbines; Taking the Sag Out of a Tight Line. E. G. Barker. Power, 58: 10, 379, September 4, 1923. A method quickly and positively applicable to any point in a tight line for producing the correct distance for vertical measurements of alignment.—*Aug. G. Nolte.*

Locating Brushes on the Neutral of Interpole Machines. B. A. Briggs. Power, 58: 10, 381, September 4, 1923. Different methods of finding neutral point on commutator of interpole motors and generators; other factors that must be considered to locate brushes properly, also discussed.—*Aug. G. Nolte.*

How to Check Instrument Transformer and Meter Connections. V. H. Todd. Power, 58: 11, 413, September 11, 1923.—*Aug. G. Nolte.*

Finding the Coefficient of Expansion and Compression on Indicator Diagrams. H. Schreck. Power, 58: 11, 421, September 11, 1923.—*Aug. G. Nolte.*

Fuel Oil and Viscosity. M. G. Langham. Power, 58: 11, 423, September 11, 1923. Practically any kind of fuel oil can be burned under a boiler provided it contains enough volatile material to ignite readily and is fluid enough to flow to burner. Sizes of pipe lines, pumps, heaters, and capacity of burners are dependent to great extent on viscosity of oil. Fuel oils vary widely in viscosity characteristics. To obtain maximum capacity, oil must be of right viscosity when it reaches burner. Oil burner manufacturers have realized this and one of the leading manufacturers recommends for his burners that viscosity of oil reaching atomizer be held at about 8 degree Engler, equivalent to 30.5 seconds Furol. Various grades of fuel oil must be heated to various temperatures to meet the specifications. Some grades would require no preheating. For maximum efficiency every precaution should be taken to maintain oil at correct viscosity. As viscosity may change during storage, it is desirable to take viscosity reading after oil has been in storage at temperature under which it is to be removed for use. Flash point of oil must be watched, in that, if temperature runs too high in storage tanks, there is possibility

of fire. Occasionally oil may be heated under pressure to prevent vaporization when heated above its flash point. Flash point is sometimes a limiting factor. Concludes that viscosity is important factor in handling of fuel oil and close attention to it would decrease annual waste of fuel oil and improve conditions of combustion.—*Aug. G. Nolte.*

Pumping Hot Water with the Aid of a Vacuum. H. W. Geare. Power, 58: 11, 427, September 11, 1923. Illustrated.—*Aug. G. Nolte.*

Pouring and Fitting Babbitt Linings. A. Hoyt Levy. Power, 58: 13, 484, September 25, 1923. Article tells of nature of babbitt metals, how to renew linings, bearing troubles and their causes.—*Aug. G. Nolte.*

Testing Resistance to Emulsification. Power, 58: 13, 493, September 25, 1923. The improved Herschel emulsifier is illustrated and its operation described.—*Aug. G. Nolte.*

The Storage of Bituminous Coal. Power, 58: 13, 513, September 25, 1923. From paper by W. L. Abbott read before annual convention of National Association of Stationary Engineers at Buffalo, September 13, 1923. Following items are discussed: (1) interest charges on investment during time coal is in storage; (2) cost of handling; (3) loss of value, due to degradation; (4) fire risk.—*Aug. G. Nolte.*

Furnace Setting for Oil-Fired Boilers. G. C. Adams. Power, 58: 14, 531, October 2, 1923. In design of furnace, lessening of losses by decreasing excess air entering furnace and distribution of fire evenly over entire surface of firebox are important points to be considered.—*Aug. G. Nolte.*

Burning Oil in a Stoker Furnace. A. A. Fette. Power, 58: 14, 535, October 2, 1923. During erection of New Iberia, La., plant of the Chas. Boldt Paper Mills, fuel oil was offered at rate that was attractive compared with coal, so it was decided to provide facilities for handling either coal or oil. Construction is illustrated and described.—*Aug. G. Nolte.*

Relation of Pressure and Velocity in Various Types of Steam Turbines. F. P. Hodgkinson. Power, 59: 12, 444, March 18, 1924.—*Aug. G. Nolte.*

Making a Power-Plant Heat Balance. T. Maynz. Power, 59: 12, 450, March 18, 1924. Equations and diagrams for computing various losses and obtaining heat balance for the power-plant.—*Aug. G. Nolte.*

Modifications of Tester for Oils. G. A. de Graaf. Power, 59: 12, 456, March 18, 1924. A modified "open cup" tester for flash and fire points is illustrated and described, which enables operator to obtain close checks on duplicate samples.—*Aug. G. Nolte.*

Fuel Oil or Coal for Steam Generation. F. H. Daniels. Power, **59**: 12, 463, March 18, 1924. Extract of paper read before New England Wholesale Coal Association, February 13, at Boston, Mass. Conclusion is, that fuel oil cannot compete with coal for generation of steam in land plants, except for the short periods of time when overproduction gluts oil markets, or when strike conditions upset coal production. Fact that relative reserves of coal and oil are in ratio of 1370 to 1, makes it quite clear also the the short periods when oil has the advantage will in future become less and less frequent and of shorter duration.—*Aug. G. Nolte.*

Use and Abuse of Powdered Fuel for Stationary Boilers. J. E. Muhlfeld. Blast Furnace and Steel Plant, **10**: 353–5, 1922. From Chem. Abst., **16**: 3381, October 10, 1922. General review of factors which have retarded development of powdered fuel, with suggestions for further improvement. Combustion should be regulated so that ferric oxide is produced, rather than ferrous sulfide. Radiant heat effects of powdered fuel, owing to glowing particles and increased refractory surfaces, offer 20–30 per cent, as possible increase in obtainable thermal efficiencies.—*R. E. Thompson.*

Higher Steam Pressures or Pulverized Coal? F. A. Scheffler. J. Am. Inst. Elec. Eng., **41**: 346–50, 1922. From Chem. Abst., **16**: 3381, October 10, 1922. Comparisons are made of 100,000 Kw steam plants. It is shown that, with much lower capital cost, even better thermal plant efficiency will pertain with use of pulverized coal and lower steam pressure, than would be the case with higher steam pressure plant, stoker fired.—*R. E. Thompson.*

Keeping Down Furnace Losses. R. T. Haslam. Power, **55**: 372–5, 1922. From Chem. Abst., **16**: 3381, October 10, 1922. Certain amount of excess air is necessary for most economical boiler operation. Charts given, wherefrom correct amount excess air may be calculated, after analyzing flue gas with Orsat apparatus and determining stack temperature.—*R. E. Thompson.*

Imperfect Combustion and the Regulation of Firing. Haarmann. Feuerungstechnik, **10**: 173–6, 1922. From Chem. Abst., **16**: 3381. October 10, 1922. Every recorded percentage of carbon dioxide corresponds to two firing conditions, one in region of excess air, other in region of imperfect combustion. Heat loss much larger in latter case. Carbon dioxide recorders alone not sufficient, but must be accompanied by recorder for unburned gases.—*R. E. Thompson.*

Standard Methods of Testing Materials. F. Becker. Paper Trade J., **74**: 15, 307 ff., 1922. From Chem. Abst., **16**: 3392, October 10, 1922. Recommendations for analytical methods for aluminium sulfate, basicity or acidity of alum, and lime for causticizing.—*R. E. Thompson.*

Partition of Chlorine Between Water and a Gaseous Phase. W. S. Titov. Nachr. Physik.-chem. lab. Semsoinsés, 1917, 102–10. From Chem. Abst., **16**: 3020, September 20, 1922. Partition of chlorine at 20 degrees between

water and air containing this gas is given by formula $(y - 1.748)^3 x^2 = (72.52)^2$, where x is volume of chlorine per thousand volumes of air and y the volume dissolved in water under corresponding partial pressure—e.g., when $x = 10$ parts per thousand, $y = 74.27$ under partial pressure of 7.6 mm.—*R. E. Thompson.*

Reactions of Caustic Soda with Aluminum Salts. EDOUARD GROBET. J. chim. phys., **19**: 331–5, 1922. From Chem. Abst., **16**: 3041, September 20, 1922. Conclusions of investigation in 1916 were: aluminum hydroxide is never precipitated pure, but is always contaminated with aluminate; aluminate is produced when 4 molecules of sodium hydroxide are present to 1 atom of aluminum; aluminate $Al(ONa)_3$ is formed by precipitating alum solutions. This work was repeated using concentrated solutions. Compounds formed on addition of sodium hydroxide to solutions of various aluminum salts are given. —*R. E. Thompson.*

Analysis of Lithia Water. D. BUTESCU. Bull. soc. chim. Romania, **4**: 26–34, 1922. From Chem. Abst., **16**: 3149, September 20, 1922. The water originated at source of the Tamaseu, Bihor, Transylvania.—*R. E. Thompson.*

Bacteriological Examination of Water. W. C. DE GRAAF. Tijdschr. vergelijk. Geneeskunde, **7**: 108–29, 1922. From Chem. Abst., **16**: 3149. September 20, 1922. Determination of number of bacteria per c.c. uncertain. Cultivation at 35 degrees for 3 days gives most constant results. Fermentation at 45 degrees, according to Eijkman, used for identifying bacteria of intestinal origin, this method being based on the fact that thermoresistant bacteria capable of fermenting glucose and characterized by positive methyl red reaction and negative Vosges-Proskauer reaction exist in the intestine. Only B. Coli will ferment glucose under conditions prescribed by Eijkman.—*R. E. Thompson.*

River Pollution from Milk Depots. WM. G. SAVAGE AND D. R. WOOD. J. State Med., **30**: 307–16, 1922. From Chem. Abst., **16**: 3149, September 20, 1922. Milk wastes are equivalent to approximately 150 times quantity of ordinary sewage and may create serious nuisance by discharge into water courses. Whey is more objectionable than washings containing milk, and is very difficult to treat. Simple storage, storage and chemical treatment, land treatment and biological methods were found unsatisfactory. Washings from floors, churns, etc., may be treated by ordinary biological processes.—*R. E. Thompson.*

Control of Steam Boiler Operation. GERMER. Industrie u. Technik, **22**: 3, 1922; Gas u. Wasserfach, **65**: 220–1, 1922. From Chem. Abst., **16**: 3150, September 20, 1922. Worm wheel and velocity type meters unsatisfactory for warm water, owing to error introduced by scale formation on delicate parts. "Volume" meters recommended, and for larger installations Venturi meters.—*R. E. Thompson.*

Modified Method for the Determination of the Hardness of Waters by Means of Soap Solutions. V. Crasu. Bul. Soc. Romana Stiin., 26: 39–44, 1923. Chem. Ind., 43: 16, B 310, April 18, 1924. Usual methods for determination of hardness of waters involve maintenance of soap solutions of exact strength, and necessitate strictly standardised experimental conditions. Author describes method whereby these disadvantages may be overcome without appreciable loss of accuracy. A solution containing 10–12 grams per litre of any suitable soap in 56 per cent alcohol is filtered after standing for 24 hrs., and standardised against a water of known hardness (prepared with calcium or barium chloride) in following way. Gradually increasing quantities of the standard hard water are placed in a series of similar test-tubes, and each portion is diluted to same volume with distilled water. Each portion is treated with same volume of soap solution, shaken, left for 15 minutes, vigorously shaken a certain number of times, and then left for 5 minutes, after which height of foam is measured. The hardness corresponding to a column of foam 1 cm. in height is thus determined. The determination of the hardness of any water is then carried out in exactly same way, by adding increasing amounts to a series of test-tubes, treating each portion precisely as in standardisation experiments, and thus determining amount of water required to produce a column of foam 1 cm. high, from which hardness can be calculated by simple proportion.—*A. M. Buswell.*

Water-Softening by Means of Doucil. T. P. Hilditch and H. J. Wheaton. Inst. Mech. Eng. and Chem. Eng. Group, 26.2.24; Engineering, 117: 287–288, 1924; Chem. Ind. 43: 16, B 310, April 18, 1924. The base-exchanging compound, doucil, or sodium alumino-silicate, resulting from interaction of dilute solution of sodium silicate (containing 2–4 mols of silica to 1 of soda) and dilute sodium aluminate, washed, and dried (cf. E. P. 177, 746; J., 1922, 372A) conforms closely when anhydrous to composition, Na_2O, Al_2O_3, $(SiO_2)_5$. Of the 13.3 per cent Na_2O present, 10.0 per cent is completely replaceable alternately by lime, and the lime in turn by soda. Complete replacement cannot, however, be effected with simultaneous production of completely softened water, and for practical purposes, particularly where water of zero hardness is required, calculations should be based upon exchangeable soda equivalent to 4 per cent of weight of anhydrous doucil present. To obtain high base-exchange capacity, the doucil should be used in plant designed so that all the material is evenly exposed to flow of water. In the manufacture, by careful adjustment of concentrations of aluminate and silicate solutions and of their respective soda contents, and by suitable mixing devices, a perfectly homogeneous gel of the alumino-silicate is prepared; the gel is transferred with as little disturbance as possible to a dryer and slowly dried over a period of 4–5 days, during which the water content is reduced from 90 to 50 per cent; the hard gel, in the form of lumps about 2 inches diameter, is then washed in a slow stream of distilled water, subjected to further drying treatment for about one day, and crushed to a convenient size. For use, material of $\frac{1}{8}$ to $\frac{1}{20}$ inch is the most suitable, and with adequate pipe arrangements for securing an even flow of water into and out of the container, with granules of this size a supporting bed of gravel or other inert material is not necessary. Granules $\frac{1}{20}$

to $\frac{1}{30}$ inche size, can be used for a top layer in a filter. Depth of bed may be largely a matter of convenience, but a bed 6 feet deep will soften to zero hardness a larger volume of water (15–20 per cent more) then two beds of the same area 3 feet deep. The salt consumption, in the regeneration, is much reduced by using the last portion of the brine from one regeneration as the first half of the brine for the next regeneration (cf. E. P. 203,497; J., 1923, 1094A). With this modification, salt consumption is about 8 lbs. per 1000 gals. of completely softened water of original hardness 20 pts. CaO per 100,000. The quantity of water used for salt solution (5 per cent brine), washing, and occasional back-flushing, is approximately 5 per cent of water softened. Time required for regeneration and washing is about an hour. On basis of exchangeable soda equivalent to 4 per cent of anhydrous doucil present, 1 ton of commercial doucil, containing 50 per cent of moisture, will soften to zero hardness, about 22,000 gallons of water containing hardness equivalent to 20 pts. CaO per 100,000 (25 grains, $CaCO_3$ per gallon), and for this purpose a plant capacity of about 64 cubic feet is necessary (35 lbs. of commercial doucil per cubic foot); a doucil bed 6 feet deep in a cylindrical shell, 3 feet 6 inches diameter by 8 feet high, with brine tank to hold 360 gallons will meet the requirements. Method is applicable for all ordinary and average waters, for supplies for laundry, dyeing, bleaching, and other works, and for boiler-feed water for steam pressures up to 120 pounds per square inch.—*A. M. Buswell.*

The Well-Water System of St. Petersburg, Florida. R. E. Ludwig. Amer. City, 30: 497–9, 1924. St. Petersburg with a summer population of 20,000, and a winter population of 75,000, derives its water supply from wells which tap a honeycombed limestone lying 200 feet below the surface and overlaid by impervious flint stratum. Well water contains "Sulphur" (hydrogen sulfide gas) sufficient to give objectionable taste. Excessive drafts are apt to draw in salt and wells tapped below 200 feet are salty. Until 1921, air-lift pumping was used and gave a maximum yield of 2000 gallons per min. To meet rapidly increasing demand for water, new works have been installed, comprising 6 Layne and Bowler wells, aerating devices, and pressure pumps. Flexibility, to meet great variation in demand, and economy of operation were the factors in decision to replace air-lift by vertical turbine pumps. Layne pumps are set 60 feet below surface, at estimated ground water level, and are driven by A. C. motors direct-connected by vertical shaft and flexible coupling. Wells located in residential section are housed in attractive structures 10 x 10 feet in plan with tiled roof. Layne pumps discharge into two storage reservoirs or receiving basins, from which pressure pumps take suction. Aerator consists of vertical riser pipe surmounted by wooden cascade or step arrangement. Its use practically eliminates the hydrogen sulfide. Pump station of attractive design, with tiled roof, houses 4 motor-driven centrifugal pumps, of 1,500 gpm. capacity each, together with auxiliary equipment and chlorinating apparatus. Power is available either from municipal plant, or from utility company. Pumps arranged to operate in parallel or series to give normal pressure of 45 pounds or fire pressure of 90 pounds. In addition there are two

300 h.p. gasoline engines. One is connected with generator having sufficient capacity to drive the six well pumps; other is connected to 6,000 gpm. centrifugal pump taking suction from receiving well or from nearby lake formerly constituting supply. Tests showed power consumption of 0.42 k.w.h. per 1000 gals. on well pumps and 0.54 k.w.h. per 1000 gallons on pressure pumps; or a total of 0.96 k.w.h.—*W. Donaldson.*

Liability for Supplying Impure Water. A. L. H. STREET. Amer. City, **30**: 506, 1924. Five decisions are cited where court has upheld liability for sickness on account of furnishing impure water, as follows: (1) New York Court of Appeals, Canavan vs. City of Mechanicville, 128 Northeastern Reporter, 882; (2) New York Court of Appeals, Stubbs vs. City of Rochester, 124 Northeastern Reporter, 137; (3) Minnesota Supreme Court, Keever vs. Mankato, 129 Northwestern Reporter, 158; (4) New Jersey, Jones vs. Mt. Holly Water Company, 93 Atlantic Reporter, 860, and (5) Wisconsin Supreme Court, Green vs. Ashland Water Company, 77 Northwestern Reporter, 722.—*W. Donaldson.*

Oil Burning Equipment in Wilmington Water Works. ANON. Amer. City, **30**: 514, 1924. Figures for oil burning equipment installed under two boilers at Wilmington, Del. in 1922 show that oil at 4 cents per gallon costs more than coal at $6.91 per ton. Relative costs for year were coal, $6.61, and oil, $7.58 per million gallons pumped.—*W. Donaldson.*

The Use of Iodine in Public Water Supplies. J. W. ELLMS. Amer. City, **30**: 516–17, 1924. (From paper before Ohio Conference on Water Purification at Columbus). Clear and concise statement of problem, with special reference to Rochester practice of iodizing its water supply for prevention of goiter. Author believes treatment of the individual to be preferable to medication of entire water supply, on the grounds both of effectiveness and of cost.—*W. Donaldson.*

Do Your Meter Readers Read Meters? ANON. Amer. City, **30**: 533, 1924. Maywood, Ill., with 18,000 population, found that only 10 per cent of its meters were read correctly during past three years, resulting in estimated loss of $40,000. Too much dependence on one man.—*W. Donaldson.*

Underground Water Waste Detection Work in New York City. FRED B. NELSON. Municipal Engrs. Jour., **10**: 23–36, 1924. An assistant engineer of Dept. of Water Supply, Gas, and Electricity describes the water waste investigations from 1902 to date. Systematic study dates from 1910. Present organization consists of assistant-engineer-in-charge and field force including two assistant engineers, two rodmen, four caulkers, and 12 laborers, divided into four field parties with motor truck equipment. Aquaphones, pitometers, and wireless pipe locators are part of the equipment. Even the thermometer has been found useful in distinguishing between leaks from Croton and Catskill mains, or between city and ground water. Unique use of aquaphones was determining from boat soundings location of a leak in submarine main. For

pitometer work over 300 gaging stations have been established and calibrated. To date, special waste detection service has found and corrected underground leakage of 129 mgd. and it is considered that present water consumption of 700 m.g.d. would be 100 m.g.d. higher in absence of such a work. Leaks of ½ m.g.d. have been found without any surface indication and some leaks were detected which had existed 10 to 15 years. Estimated cost of waste detection has varied from $1.15 to $6.34 per million gallons saved, with 1922 cost of $3.62.—*W. Donaldson.*

The Control of Waste from Water Fixtures by House-to-House Inspection in New York City. Edward Neubling. Municipal Engrs. Jour., 10: 37–51, 1924. Under present laws there is no authority for installing meters on private dwellings and only small portion of domestic consumption is metered. Estimated leakage from water fixtures, if unchecked for several years, is 20 per cent of total supply. Continuous house-to-house inspection has not been carried out, but since 1910 special inspections have been made from time to time on account of threatened water shortage. On account of intermittent nature of inspections, no permanent organization exists. Work is under direction of the Chief Inspector of Bureau of Register, who has under him a chief inspector for each borough. One house-to-house inspector can examine 8 buildings in a day, and it would require 120 inspectors to cover the city in a year. Inspection work is by squads of 12 men, each under a supervising inspector. One clerk is required for every five men in the field. Special forms are provided for recording inspection and notifying owner of wastage. Fine of $2.00 is imposed for failure to repair leaks. Author presents a formula for determining reduction in consumption under different conditions of inspection. Economical size of force is one which will cover city in two years. Such force in New York will cost about $4.50 per million gallons of water saved.—*W. Donaldson.*

The Graphitic Softening of Cast Iron. J. W. Shipley and I. R. McHaffie. Ind. Eng. Chem., 16: 6: 573, June, 1924. Dependent upon a frame-work structure of non-corrosive compounds formed in manufacture, namely, pearlite and cementite, which holds in place the graphite left after the iron has passed into solution and disappeared. Ferrite in contact with graphite easily loses iron into solution because of marked potential difference (0.56 V) between these substances. Pitting and graphitic softening occurred always in areas containing ferrite and graphite. Examination of unattacked areas showed graphite embedded in pearlite, with ferrite absent. White cast iron, in which ferrite is absent and all carbon in combination, corrodes little, if any. Wrought iron corrodes out of face, the metal becoming increasingly thin, there being no appreciable content of carbon, or other resistant compounds, to form a supporting structure. Micrographs reproduced show course of corrosion and structures which are left.—*Linn H. Enslow.*

Determination of Nitrate Nitrogen. F. M. Scales and A. P. Harrison. Ind. & Eng. Chem., 16: 6, 571, June, 1924. Improved method, based on production of a rose color, when a reduced solution of strychnine sulfate is

added to solution containing nitrate ion in presence of excess sulfuric acid. *Advantages:* interference due to colored extracts practically eliminated: only a small quantity of unknown required: chlorides do not interfere: suitable in presence of most soluble organic matters. *Disadvantages:* reduced strychnine reagent only stable for a few hours: color intensity increases slowly in the dark, but fades in the light: presence of lead, zinc, or mercury, will interfere: great care required in preparing strychnine reagent.—*Linn H. Enslow.*

Making Lead-Lined Pipe. Chem. & Met. Eng., 30: 9, 351–3, March 3, 1924. Lining of iron pipes with lead is done by 2 methods—cast, and tube-lined. Latter is more resistant to corrosion by acids. In manufacture of cast-lined pipe, the iron is first pickled and galvanized, for lead will not alloy directly with iron. The pipe is placed on an inclined rack with a mandrel inside at lower end, attached to a small pipe extending through the pipe to be lined. A quantity of molten lead is poured into the top of the feed pipe, which runs to the lower end. The pipe is then drawn through a quenching ring, concentric with the mandrel, where jets of water play upon the outside and solidify the lead. The hot lead above the quenching ring is kept fluid by a series of gas burners. Tube-lined pipes are made by expanding a lead tube into the iron pipe and sweating or soldering the two together. The pipes are heated from the outside while the expander is revolving. In lead-lined fittings cast iron cores are used and the whole submerged in molten lead.—*John R. Baylis.*

The Powers, Duties and Policies of the Sanitary Water Board. W. L. Stevenson. Pennsylvania W. W. Assn. 1923 Report. Page 27. "The Administrative Code," approved June 7th, 1923, created in Department of Health, the Sanitary Water Board, vested with jurisdiction over pollution of waters of State. Streams now relatively clean and pure shall be so maintained, and their cleanliness extended, excepting Mine Drainage. For streams now partially polluted, economics demand the inoffensive assimilation of a certain amount of polluting matter, under scientific method of disposal by dilution. Sanitary Water Board will confer privileges and impose obligations upon municipalities. Problem must be approached with recognition of financial aspects. For streams now highly polluted, it is no longer economical to restore them to purity.—*E. E. Bankson.*

Stream Pollution Problems. J. N. Chester. Pennsylvania W. W. Assn. 1923 Report. Page 52. True rule may be stated to be, that each riparian proprietor has right to have stream flow through, or pass, his land with its quality unimpaired and its quantity undiminished, except from a *reasonable* use of stream by riparian proprietors above him. **Domestic Pollution Problems Covered by Paper of W. L. Stevenson, 1924.** Mine Drainage Problem solution is indicated by court's decision in case of Mountain Water Supply Company et al. vs. Sagamore Coal Company et al., in part as follows: "The coal companies have brought nothing onto the land artifically." "The neutralization and softening, or other treatment, of the waters of Indian Creek will not entail an unreasonable burden upon the water companies." "The

drainage by the coal companies is a proper and natural use of their lands and constitutes a right of property." "The granting of an injunction against the coal companies would deprive them of their rights without due process of law." Mill and factory waste, including coke by-products, is an artificial use of land and, therefore, not in a legal class with coal mining operations.—*E. E. Bankson.*

Water Works from the Viewpoint of the Investor. W. R. Voorhis. Pennsylvania W. W. Assn. 1923 Report. Page 69. The American Water Works & Electric Company has been offering preferred stocks of its subsidiary companies to consumers in territory served. Investments have ranged from $50,000, by one investor, to one share upon basis of $5.00 down and $5.00 per month. Service of waterworks is indispensable part of our daily life. It is a safe business in that its fundamental methods remain very much the same; no change in art, style, or mode, affects them. Investment is in property which endures for generations; which serves a continuous and increasing demand, is not much benefited by business booms, nor greatly affected by business panics; is not the field of exploiter, or of profiteer; but where reasonable service is awarded a just compensation.—*F. E. Bankson.*

Public Relations from a Newspaperman's Viewpoint. J. S. S. Richardson. Pennsylvania W. W. Assn. 1923 report. Page 80. You have to overcome that fear which breeds suspicion, the suspicion which breeds hate, and the hate which breeds bitter controversy. This you can only do by coming out in the open, in the spirit of friendliness, and in a frank way telling the people your story, and especially teaching the youngsters who are coming along.—*E. E Bankson.*

Public Relations from the Utilities Viewpoint. Theodore J. Grayson. Pennsylvania W. W. Assn. 1923 Report. Page 95. It is basically untrue that any portion of the American people is fundamentally unfair. They are basically a fair race; but average politician is moral coward. We must devote ourselves to educating public as to the main points of public utility service. Some very successful experiences are related, all summarized in these words: "Do unto others as you would have them do unto you."—*E. E. Bankson.*

Public Relations from the Public Viewpoint. H. E. Carmack. Pennsylvania W. W. Assn., 1923 Report. Page 118. Who is the public? Perhaps eighty per cent of your customers belong to the "silent public," the remaining twenty per cent being made up of the "knocking public," the "ignorant public," the "complaining public" and the "dishonest public." Show them how you run your plant. Put your cards on the table. Do not ask for any more than you are justly entitled to. Then you are on solid ground.—*E. E. Bankson.*

The Reasonableness and Equity of Service and Minimum Charges. Morris Knowles and Nathan B. Jacobs. Pennsylvania W. W. Assn. 1923 Report. Page 149. Theoretically, the design of a rate schedule is to apportion cost of

service between consumers upon basis of each individual's share toward cost of operating system. There is difference in opinion as to proper method. Minimum charge includes all the capacity, consumer, or readiness-to-serve, costs and a little more, namely, a certain quantity of water. Where the minimum is placed to include only 1000 to 2000 gallons per month, the general trend and direction of the rate can be worked out to be almost identical with that of the readiness-to-serve schedule. This leads to conclusion that, in most cases, minimum charge schedule when correctly designed is fair and equitable both to utility and to consumer. Service charge not being understood, it is better that there should be a minimum charge. Discussion by Mr. Chester: There are states such as Ohio where Public Service Commission will not support servica charge. The Public Service Commission in New York State said that minimum charge was illegal, that it discriminated; which service charge did not do. By Mr. Walker: It is now generally conceded that it is essential to make a substantial service charge in order to secure equitable rates for all. Suggestions and recommendations in favor of minimum charge are a step backward, rather than toward progress. Either service charge is right, or it is not right. If it is right, we should have no hesitancy in establishing our rate schedules accordingly. There is no question as to its merits as a definite, clear cut, and business-like proposition. It gets down to brass tacks and eliminates unsound bickering and dickering features of minimum. By Mr. Ledoux: Ready-to-serve charge is honest and logical method. Minimum charge recognizes same principle, but is subterfuge, as sop to consumer. By Mr. Bankson: "The plant capacity chargeable to demand cost (of service charge) is the surplus capacity of the system which represents the capacity required to meet unusual or spasmodic demands." Basis for stand-ready portion of service charge is "surplus portion of the plant and ~ portion of operation created by spasmodic demands." Theoretical and correct service charge for gravity plant would usually be noticeably less than for pumping plant.—*E. E. Bankson.*

The Construction of Rate Schedules. H. E. Ehlers. Pennsylvania W. W. Assn. 1923 Report. Page 191. First duty of public service company is to render adequate service, for which it is entitled to collect reasonable charges. Construction of schedule of rates must involve certain amount of compromise: is complex problem, calling for fullest cooperation of utility rate expert and local management, and for exercise of fully informed and experienced judgment. Two properties quite similar in general characteristics, size, and cost, may show widely different rate levels because of industrial load and consumers per mile of main. Rate requirements, or preference, can have no legitimate influence on cost analysis, which is a separate and distinct thing, subject to enough difficulties without unjustifiable influence of rate problems. Not all investment costs are attributable to "capacity" cost. For example, size of a storage reservoir is far more controlled by average, than by maximum demand. No property can be exactly proportioned in every item to the needs of the moment; some portions may have considerable margin, or reserve; other portions may be at their limit, or even deficient. Conclusions: (1) Importance of rate structure demands thorough study and analysis. (2) Results of cost

analysis do not constitute rate schedule, but rather a frame work, to be covered and rounded out by consideration of numerous other factors. (3) Cost analysis should be free from influence of and distortion by rate considerations. (4) Knowledge of characteristics of the service and of its operation, and of the development of the property is essential. (5) Decision as to form and proportions of rate schedules should be on basis of the particular local situation and its expected development.—*E. E. Bankson.*

Legislation of 1923. Philip P. Wells. Pennsylvania W. W. Assn. 1923 Report. Page 218. Summary of revision and coordination effected by Administrative Code with reference to powers of Department of Forests and Waters, as a department, and to Water and Power Resources Board.—*E. E. Bankson.*

Decision of the Courts and Public Service Commission of Pennsylvania During the Year, Affecting Water Companies. Edgar Munson. Pennsylvania W. W. Assn. 1923 Report. Page 230. (A) One Judicial tribunal shall exercise "independent judgment" upon the law and the facts, only when a question of confiscation is involved. (B) When consumer, without demand upon company, voluntarily lays his own service pipe, Commission cannot order company to make reparation for cost thereof. (C) Expenses before Commission amortized over period of three years. (D) Accrued Depreciation, not deducted from historical cost. (E) Free Service for right of way, and Free Service to Directors of Company held by Commission as "unfair, discriminatory, and economically unsound." (F) Regarding Extensions, Commission decided each case upon its own merits. (G) Regarding Mine Water Pollution, Court held that, unless there has been a legal condemnation of the waters of stream, and of rights of riparian owners therein, neither the Commonwealth, nor a company created for private purposes, has any right to enjoin upper riparian owners from lawful exercise of their riparian rights. (H) State tax on bonds is not allowed as operating expense; but Federal Income Tax is so allowed. (I) Contract Rates and Ordinance Rates are superseded by new tariff. (J) Valuation, for Rate Making Purposes, is the present fair value of property used and useful in the public service, including consideration of potential usefulness. (K) Review of other miscellaneous decisions.—*E. E. Bankson.*

Recent Federal Decisions. Joseph A. Beck. Pennsylvania W. W. Assn. 1923 Report. Page 270. Attempt made by Mr. Justice Brandeis, of the United States Supreme Court, in case of Galveston Electric Company vs. Galveston, 258 U. S. 388, decided April 10, 1922, to establish the prudent investment as determining factor in valuation of a public utility's property in a rate case, has not been supported by later decisions of U. S. Supreme Court, such as Southwestern Bell Telephone Case and Bluefield Water Case, where Courts held that present day costs must be given consideration and weight in fixing fair present value. Other lower courts have later followed this definition of the law.—*E. E. Bankson.*

Water Deactivation. F. N. Speller. Proceedings Eng. Soc. West. Penna. 39: 189, 6 July, 1923. In most waters, corrosion is proportional to free oxygen content. Describes briefly the development of means of control of corrosion by removal of free oxygen from water.—*E. E. Bankson.*

Algal Growths in Tank Waters and the Effect on Them of the Removal of the Dissolved Bicarbonates of the Water by the Addition of Sulphuric Acid. V. Gobinda Raju. Indian Journal of Medical Research, II: 4, 1057, April, 1924. An attempt to remove ignorance of algae types in India by study of their growth in tank waters. A temperature of about 75°F. appears to be most suitable for their growth. Growth was most abundant in shallow tanks, which had large amount of decomposing organic matter at bottom and sides. Experience in Bengal does not confirm the generally accepted notion that copper sulphate possesses marked algicidal properties. The experience was distinctly disappointing with this chemical. Use of lime, even in excess, was unsuccessful. Sulphuric acid, added in sufficient amount to neutralise all the bicarbonates present, renders water totally unfit for algal life. The forms present are killed and precipitated. The water need not be rendered acid. The treatment is based on the assumption that algae make use of CO_3 and bicarbonates for food purposes. The elimination of the latter removes source of food supply. Most common forms of algae found were species of oscillaria, anabena, cylindrospermum, navicula, euglena and spirogyra.—*Abel Wolman.*

Some Further Observations on the Species Method of Differentiating Fecal Organisms in Surface Waters in the Tropics. A. D. Stewart and V. Gobinda Raju. Indian Journal Medical Research, II: 4, 1157, April, 1924. Studies were made to check earlier observations and suggestions of Clemesha regarding variations in water organisms of varying origin. Findings indicate that B. Coli communis is about the commonest organism in recently polluted waters or crude human feces and at the same time the rarest fecal organism in waters which have been subject to prolonged storage. In freshly polluted water or crude human feces a large number of species is met with. In waters after prolonged storage only one or two species are encountered. This fact of altered ratios offers an added diagnostic index of degree of storage.—*Abel Wolman.*

Note on the Appearance of a Violet Producing Organism in Certain Water Supplies of the Madras Presidency. J. Cunningham and T. N. S. Raghavachari. Indian Journal Medical Research, II: 4, 1285, April, 1924. Sudden appearance of violet-producing bacteria in three water supplies is noted, although 16 years of observation of these supplies had not disclosed similar type. Tracing of origin was unsuccessful. Organisms are similar to B. violaceum, described by Lehmann and Neumann, but differ in that the three strains here isolated are gram negative and do not produce indol.—*Abel Wolman.*

Recent Developments in Sanitary Engineering. George W. Fuller. Can. Eng., 45: 18, October 1923. Paper presented in England at annual

meeting of Institution of Sanitary Engineers. Present U. S. status in purification of water and sewage disposal reviewed. Comparison of European and American methods of garbage and refuse disposal.—*N. J. Howard.*

Colorimetric Test for Sands. Abstract from Concrete Data for Engineers and Architects, Can. Eng., 45: 19, November 1923. Important characteristics of sand for use in concrete are durability, cleanness, and grading. In particular, sand must be free of organic coating. Field test consists in shaking sand with dilute solution of sodium hydroxide, letting stand for 24 hours, and noting color of clear supernatant liquid. Washing greatly reduces organic impurities present in sand which are concluded to be generally responsible for defective qualities.—*N. J. Howard.*

Centrifugally-Cast Reinforced-Concrete Water Pipe. W. G. Chace. Can. Eng. 45: 20, November 1923. Description of outfit required for manufacture. Construction of reinforcing cage of steel wire, triangular mesh, for water pressure pipes is described. Account is also given of flexible joint provided for contraction.—*N. J. Howard.*

Turbines at Raanaafoss Power Station, County of Akershus, Norway. Hallgrim Thoresen. Can. Eng. 45: 25, December 1923. Excellent description of important hydro-electric development in Norway. Six turbines produce total output of 72,000 h.p. at 40 feet head and 107 r.p.m. with water consumption of 3200 cubic feet per second. Guaranteed efficiency of turbines was exceeded in each case.—*N. J. Howard.*

Effect of Alkali soils on Concrete Structures. G. M. Williams. Can. Eng. 45: 25, December 1923. Article refers mainly to deterioration of concrete n irrigation works in alkaline soils in arid or semi-arid sections of the western states. Such soil contains large quantities of sodium, calcium and magnesium, originating from the natural weathering of the rocks. Ground waters in such localities contain considerable quantities of these salts in solution and are classed as alkali waters. Early investigations, as reported in bulletin No. 81 of Montana State Agricultural College, indicated that disintegration of cement by alkali salts was indirectly brought about by formation of new chemical compounds of greater bulk than the $Ca(OH)_2$ replaced which forced apart the particles of cement, thus destroying the bond. Summary of investigations by Bureau of Standards showed that the best quality of mortar or concrete may be disintegrated in sulphate soils and waters. Deterioration in chloride or carbonate waters appeared to be slow, or entirely absent. Rapidity of disintegration is proportional to sulphate content of water. Frost appears to accelerate. Carbonising of lime at surface of a structure will not prevent disintegration. Tar protective coatings are not permanent. Field investigations in Canada in the Prairie Provinces confirmed work of U. S. Bureau of Standards. $40,000 has been provided by Research Council of Canada for chemical research now being undertaken. Where sulphate concentrations permanently low, good quality concrete appears to have a life which fully justifies its use. Concentration of salt in ground waters may vary widely at

points but short distances apart. There appears also to be seasonal or yearly variation in some districts. Concrete of high quality is most resistant to action. Where alkali conditions are bad, factor of safety against failure can be greatly increased by employing proper drainage precautions. Portland cement, as now constituted, is inherently subject to attack by sulphates in soil and ground water; the practical and final solution of alkali-concrete problem is dependent upon discovery of some modification of, or addition to, portland cement, which will render it immune.—*N. J. Howard.*

Design of Surge Chambers. P. E. Baumann. Can. Eng., **46**: 8, February, 1924. Description of provision against excessive oscillation of water pressure. Means for determining variation of levels and equations are given.—*N. J. Howard.*

Status of Water Supplies in Quebec, 1923. T. J. Lafreniere. Can. Eng., **46**: 9, February 1924. During year, four filtration plants were started and two completed. Chlorination only is used in 22 towns. Sources of supply: 50.5 per cent from rivers, 10.5 per cent from lakes, and 39 per cent from springs and wells. Water purification is limited to river supplies of which 73.5 per cent are filtered, 11.5 per cent chlorinated and 15 per cent untreated. Typhoid mortality per 100,000 is slightly below 12, that of City of Montreal being 6.—*N. J. Howard.*

Mechanical Filtration Plant, Lauzon, Que. H. G. Hunter. Can. Eng., **46**: 9, February 1924. Illustrated description of new plant at Lauzon.—*N. J. Howard.*

Water Motors Inject Chlorine at Moncton, N. B. J. Van Benschoten. Can. Eng., **46**: 9, February, 1924. Illustrated description of hydraulic engines operating reciprocating pumps by which chlorine solution is forced into mains. Operation unaffected by interruption in power supply, but automatically ceases if discharge lines closed.—*N. J. Howard.*

CONTENTS

CONSTITUTION OF THE AMERICAN WATER WORKS ASSOCIATION

Adopted June 12, 1913
Amended May 12, 1914
Amended May 12, 1915
Amended May 17, 1918
Amended June 9, 1921
Amended May 19, 1924

ARTICLE I

Name

The name of this Association, a corporation organized under the laws of the State of Illinois, shall be "The American Water Works Association."

ARTICLE II

Object

The object of this Association shall be the advancement of knowledge of the design, construction, operation and management of water works, and the encouragement, by social intercourse among its members, of a friendly exchange of information and experience.

ARTICLE III

Membership

Section 1. Members of this Association may be either Honorary Members, Active Members, Corporate Members, or Associate Members.

Section 2. An Honorary Member shall be one whose scientific or practical knowledge in matters related to public water supply, or whose accomplishments in that field of endeavor, shall entitle him to especial recognition by the Association. Honorary Members shall have the same privileges as Active Members, but shall not be required to make any payments for the support of the Association.

Section 3. An Active Member shall be either a Superintendent, Manager or other officer of a municipal or private water works; a civil, mechanical, hydraulic or sanitary engineer, a chemist or bacteriologist, including those acting technically as such for, and employed by, Associate Members of the Association; or any qualified person engaged in the advancement of knowledge relating to water supplies in general.

Section 4. A Corporate Member shall be a water board, water commission, water department, water company or corporation; national, state or district board of health or other body, corporation or organization interested or engaged in public water supply work and shall be entitled to one representative, whose name shall appear on the roll of members and may be changed at the convenience or pleasure of the represented Corporate Member upon written request to the secretary, who shall have all of the rights and privileges of an active member.

Section 5. An Associate Member shall be either a person, firm or corporation, engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works. An Associate Membership shall entitle the holder to be represented by one person on the floor at each meeting but such representative shall not be entitled to vote or take part in any discussion unless permission is given by unanimous consent of the members present.

Section 6. When an Active Member so changes his vocation that were he to apply for membership he would be classed as an Associate Member, he may continue as an Active Member with all the privileges of that grade, except that he shall not be eligible to any elective office in the Association.

ARTICLE IV

Admission and Expulsion

Section 1. The Executive Committee may, at its discretion, at the request of any member, present the name of any person qualified for Honorary Membership, to the Association for election to that grade of membership; but the Executive Committee must, upon the written request of twenty-five members, so present the name of any such person to the Association.

Section 2. Any person, firm, corporation or water department desiring to become an Active, Corporate or Associate Member

must make application for the grade of membership sought, upon the blank form provided by the Association. Each application must be endorsed by two members of the Association, shall embody a concise statement of the applicant's qualifications for membership and be accompanied by the initiation fees and dues as hereinafter provided. All applications must be forwarded to the Secretary, who shall submit them to the Membership Committee, as soon as possible.

A majority affirmative vote of the Membership Committee shall elect to Active, Corporate or Associate Membership subject to review by the Executive Committee.

Section 3. No member whose dues are in arrears shall receive the publications of the Association until such dues are paid. Members in arrears for one year shall be dropped from the roll by the Secretary.

Section 4. Any member who has been suspended for non-payment of dues may be reinstated by the Membership Committee upon payment of all back dues. He shall then be entitled to receive such back numbers of the publications of the Association as may have been withheld from him on account of non-payment of dues, and are not out of print.

Section 5. Any member of any grade may be expelled from the Association for cause, upon the recommendation of the Membership Committee, adopted by a two-thirds vote of the members present and voting at any annual convention.

Section 6. Any member may retire from membership by giving written notice to that effect to the Secretary, provided that he pay all dues to that date, unless released from said payment by the Executive Committee.

ARTICLE V

Fees and Dues

Section 1. Each Active Member shall pay an initiation fee of Five Dollars, and annual dues of Seven Dollars, provided that any Active Member in good standing who has paid dues continuously for thirty years shall be exempt from payment of further dues.

Section 2. Each Corporate Member shall pay an initiation fee of Ten Dollars, and annual dues of Ten Dollars.

Section 3. Each Associate Member shall pay an initiation fee of Ten Dollars, and annual dues of Fifteen Dollars.

SECTION 4. The fiscal year of the Association after the calendar year of 1924, shall begin on January 1st and terminate on December 31st. Annual dues shall be payable in advance and shall be due on January 1st, the first day of the fiscal year covered by said dues. It shall be the duty of the Secretary to notify each member on or before December 31st of the amount due from said member for the ensuing year.

SECTION 5. Any newly elected member shall be entitled to all of the publications of the Association that are distributed to the members during the year for which he has paid dues. Members elected later than October 1st shall not be required to pay the annual dues for the current year, but if they do pay said annual dues they shall be entitled to all publications to which members in good standing are entitled for that year.

SECTION 6. In case any application for membership shall he rejected the initiation fee and dues which accompanied the application shall be returned to the applicant.

ARTICLE VI

OFFICERS

SECTION 1. The officers of the Association shall be a President, Vice-President, Treasurer, Secretary, Secretary-Emeritus (if this office be filled), and Editor of the Association's publications. The offices of the Secretary and Editor may be combined at the discretion of the Executive Committee.

SECTION 2. There shall be an Executive Committee in which the government of the Association shall be vested. It shall consist of the President, Vice-President, Treasurer, Secretary, Secretary-Emeritus (if this office be filled), Editor, the Chairman of the Finance Committee, the latest two living past Presidents and nine Trustees elected to represent the nine Districts hereinafter established, one Trustee to be elected from each District to serve three years. The President and Secretary of the Association shall be the President and Secretary of the Executive Committee. In 1924 one Trustee shall be elected from District 1, to serve one year, one Trustee from District 5 to serve two years, one Trustee from District 9 to serve three years, one Trustee from District 4 to succeed the present Trustee whose term expires in 1924, and one Trustee from District 8 to succeed the present Trustee whose term expires in 1924; and every year

thereafter three Trustees shall be elected in the Districts in which the terms of the incumbents expire.

Section 3. The following Districts are established for the purpose of territorial representation:

District 1 shall consist of the Dominion of Canada.

District 2 shall consist of the States of Maine, New Hampshire, Massachusetts, Rhode Island, Vermont and Connecticut.

District 3 shall consist of the State of New York.

District 4 shall consist of the States of New Jersey, Pennsylvania and Delaware.

District 5 shall consist of the District of Columbia and the States of Maryland, Virginia, West Virginia, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama and Mississippi.

District 6 shall consist of the States of Kentucky, Ohio, Indiana and Michigan.

District 7 shall consist of the States of Louisiana, Arkansas, Missouri, Kansas, Oklahoma, Texas, Nebraska, Colorado, New Mexico, Arizona, Utah and Nevada.

District 8 shall consist of the states of Wisconsin, Minnesota, Illinois, Iowa, South Dakota and North Dakota.

District 9 shall consist of the States of Wyoming, Idaho, Montana, Washington, Oregon, California and all other Territories of the United States and all territory outside of the United States except the Dominion of Canada.

The boundary line of these Districts may be changed by majority vote of the Association at any time when it becomes necessary or desirable to do so in order to preserve an equitable territorial representation.

Should any Trustee be thrown into another District by changes made in the boundary lines or by change of residence, he shall serve out his term of office and be accredited as the representative either of his old District or of the District in which he resides, as the Executive Committee may determine.

Section 4. As the last order of business of the second session of the first day of the annual conventions the members from each District shall elect a member of the Nominating Committee to represent their respective Districts. Due notice of such election shall be given prominence in the program of the convention, which shall be mailed to the members at least three weeks previous to the opening day of the convention. The votes of the Districts shall be by ballot

and a majority vote of the members of each District voting shall elect the member of the Nominating Committee to represent that District. The members of the Nominating Committee so elected, together with the latest living past-president at the convention, who shall be Chairman, shall constitute the Nominating Committee to place in nomination candidates for the offices to be filled for the following year.

The Nominating Committee shall hold a meeting at 8.30 a.m. on the second day of the convention; previous to which time suggestions of names to fill the various offices may be made by the members of the Association to the members of the Nominating Committee, or by leaving same with the Secretary of the Association prior to the meeting of the Committee; names sent to the Secretary by mail at any time prior to the meeting of the committee shall also be presented to the Committee for consideration; Nominations shall be by majority vote of the Nominating Committee, who must place in nomination one, and may place two, candidates for each office to be filled.

On or before January 10 the Nominating Committee shall report its list of nominees to the Secretary of the Association, who shall before the first day of February cause to be mailed to the membership the list of nominees selected by the Nominating Committee. At any time prior to noon on the first day of March of each year additional nominations may be made by request to the Secretary, signed by at least twenty-five Active, Honorary or Corporate members, and upon the receipt of such request the Secretary shall, after acceptance of the nomination by the candidate, add such additional nominees to the final ballot to be prepared by him. The nominees of the Nominating Committee shall head such final ballot for each office, and any additional nominees for the respective offices shall be placed under the nominees of the Committee in alphabetical order.

Section 5. When more than one is nominated for any of the offices to be filled, either by the Nominating Committee or by request, the election shall be by letter ballot. When a letter ballot is required, at least two months before the date of the annual convention a ticket shall be mailed to each member of the Association entitled to vote. Each member shall be entitled to vote for one candidate for President, one candidate for Vice President, one candidate for Treasurer and three candidates for Trustees. The ballot shall be sealed separately in a special ballot envelope. This ballot envelope shall

be enclosed in a larger envelope and forwarded to the Secretary. The signature of the member voting shall appear on the outer envelope.

When a letter ballot is necessary the Secretary with two canvassers appointed by the President shall meet at a time and place directed by the President, and shall open and count all ballots cast by persons entitled to vote. No ballot shall be counted if received later than noon of the seventh day previous to the beginning of the annual convention. When only one candidate is placed in nomination for each office to be filled the report of the Nominating Committee shall be considered as an election.

The result of the canvass for President, Vice-President, Treasurer, and Trustees shall be declared by the President at the annual meeting on certification of the canvassing board. The members who shall have received the highest number of votes cast for the several offices shall be declared elected. If there be a tie vote the President shall order a vote to be taken in the annual convention to decide which person of those who shall have received the same number of ballots shall be chosen.

The terms of the officers so elected shall be as follows: For the President, Vice-President, and Treasurer, each one year beginning with the close of the last day of the annual convention and ending the last day of the next annual convention, or until their successors shall have been chosen; for the Trustees, three years beginning with the close of the last day of the annual convention, or until their successors shall have been chosen.

Section 6. Before the close of each annual convention the Executive Committee elected to serve during the year ensuing shall organize and elect a Secretary and an Editor and may elect as Secretary-Emeritus an active member who has served as Secretary, provided that there shall not be more than one Secretary-Emeritus at any time, to serve until the close of the next annual convention, or until their successors are chosen.

Section 7. In case of inability of the President to perform the duties of his office, his position shall be temporarily filled by the Vice-President, and in case of inability of the Vice-President, his position shall be filled by one of the Trustees; the order of precedence being governed by priority in date of election as Trustee, or if the dates of election be the same, by priority in date of the admission of such Trustees to membership in the Association.

Section 8. All vacancies in office, except as provided in Section 7 hereof, shall be filled by vote of the Executive Committee for the unexpired term of said office as soon as practicable after said vacancy occurs.

Section 9. The President, Vice-President and Trustees shall be ineligible to election to the same office for consecutive terms.

ARTICLE VII

Duties of Officers

Section 1. The President shall have general supervision of the affairs of the Association, and shall preside at all meetings of the Association and of the Executive Committee at which he may be present.

Section 2. The Executive Committee shall be the legal representative of the Association and as such shall have full control of the management of the affairs of the Association, subject to the control of the Association in regular convention; it shall make the necessary arrangements for the convention and shall have power to expend the funds of the Association or to invest the same, but must not incur indebtedness beyond the funds in the hands of the Treasurer and Secretary. The Executive Committee shall have power to prepare and enforce, for the conduct of the business of the Association, by-laws not in conflict with this Constitution. It shall hold an annual meeting at least one hour before the opening session of each annual convention. Other meetings shall be held at the call of the President or of any three members of the Executive Committee.

All questions in the Executive Committee shall be decided by a majority vote and seven members shall constitute a quorum. The Executive Committee may vote by letter upon questions submitted by the President and Secretary.

Section 3. The Treasurer shall have charge of the funds of the Association, shall pay bills against the Association on order of the Finance Committee certified by the Secretary and shall make a report of the expenditures and of the funds of the Association at the annual convention.

Section 4. The Secretary shall be an Active Member of the Association. It shall be his duty to attend all conventions and meetings of the Association and of the Executive Committee; pre-

pare the business and duly record the proceedings thereof. He shall see that all moneys due the Association are carefully collected, and shall promptly pay the same to the Treasurer. He shall personally certify the accuracy of all bills or vouchers to the Finance Committee.

He shall, at the annual convention, make a report of the receipts and of the condition and affairs of the Association.

He shall conduct the correspondence of the Association and keep a full record of the same.

Section 5. It shall be the duty of the Secretary-Emeritus to assist in building up the membership of the Association, in securing advertisers for the Journal, to attend and assist in the arrangements for and conduct of the annual conventions, and to perform such other duties as the Executive Committee may assign to him.

He shall receive for expenses and services such salary and allowance as the Executive Committee may from year to year determine and as shall be approved by the Association at an annual convention.

Section 6. The Editor shall have charge of the printing and distribution to all the members, of the Proceedings and Transactions of the Association and shall perform such other duties as are assigned to him by the Executive Committee.

The publications of the Association shall be copyrighted so far as is practicable and proper.

ARTICLE VIII

Committees

Section 1. There shall be four standing Committees, the Finance Committee, the Membership Committee, the Publication Committee and the Convention Committee. The members of each shall be appointed by the incoming Executive Committee. They shall serve for one year beginning with the close of the last day of the Annual Meeting or until their successors shall have been appointed. Special Committees may be appointed at any time by the President.

Section 2. The Finance Committee, which shall consist of three active members, shall audit and approve all bills before they shall be paid by the Treasurer. It shall examine the books of the Secretary and of the Treasurer annually or more often, and shall audit the same and report upon the same to the Executive Committee. This Committee shall have general supervision of the

finances of the Association, making such reports thereon to the Executive Committee as the exigencies of the case may require or as directed by the Executive Committee or by the Association at its annual convention.

Section 3. The Membership Committee, which shall consist of three members, shall examine the qualifications of and vote upon all applicants for membership nominated in due form, and report its action to the Secretary.

Section 4. The Publication Committee, which shall consist of five members, one of whom shall be the Editor, shall have control of the publications of the Association and shall see that all publications and papers are edited before publication, and, whenever possible, before presentation.

The Committee may call to its aid members of the Association or others who have had special experience in the subject treated, to advise in regard to any paper, or to discuss the same, and may return any paper to its author for correction or amendment.

No papers containing matter either readily found elsewhere, especially advocating personal interests, carelessly prepared, purely speculative, or foreign to the purpose of the Association shall be accepted. The Committee shall prepare rules which, when approved by the Executive Committee, shall govern the preparation, presentation and publication of all papers and such other matters of similar nature as the best interests of the Association may require.

Section 5. The Convention Committee, which shall consist of three members, one of whom shall be the Secretary or Secretary Emeritus, shall investigate all invitations to hold conventions of the Association, satisfying itself that the places extending the invitations have proper facilities for the accommodation of the members and guests, for holding the meetings of the Association with its National Divisions, and for exhibits by Associate Members. This Committee shall invite the Convention Committee of the Water Works Manufacturers' Association to cooperate with it. The Committee shall prepare and send to all cities extending invitation to hold conventions a form containing such questions as may be necessary to properly inform the Committee as to the convention facilities offered. The information shall include a diagram of the rooms offered for meeting rooms, Committee and Division rooms and exhibition space, also a list of available hotels with guaranteed rates and the number that each

will accommodate, points of interest to water works people, and entertainment, if any, offered.

During each Annual Convention the Committee shall hold a meeting, at which advocates of various places extending invitations shall be heard, and at the time designated by the Executive Committee for the selection of the place for holding the next Annual Convention the Committee shall make a report to the convention, stating in alphabetical order the invitations received and fully and impartially set forth the advantages and facilities offered by each. Should no invitations be received it shall be the duty of the Committee to ascertain what arrangements can be made for holding a convention, and to report to the Executive Committee before the convention convenes.

The Committee, or one or more members of the Committee, may, as soon as practicable after the place for holding convention has been selected, visit such placc and ascertain whether the guarantees can be fully carried out, and whether it is a suitable place for holding a convention of the Association; also, if the place is approved, to make the necessary arrangements for holding the convention. If after such visit, it is the judgment of the Committee that the place is not suitable, or does not offer proper facilities, or for any other reason it would not be for the best interests of the Association to hold its convention there, the Committee shall immediately report its findings to the Executive Committee, with its recommendations as to the meeting place for the next annual convention. The expenses of the Committee or members of the Committee, in making such visits, to be borne by the Association, on the basis of an allowance of four cents per mile travel.

ARTICLE IX

Meetings

Section 1. The annual convention of the Association shall open on such Tuesday as the Executive Committee may designate and at such place as shall have been designated by the Executive Committee after receiving the recommendation of the Convention Committees.

Section 2. The Executive Committee shall have power to change the place of meeting as in its judgment the interests of the Association may demand.

SECTION 3. The date of the Annual Convention shall be fixed by the Executive Committee not less than seventy days in advance of the meeting, and such date shall be printed on all ballots for the nomination or election of officers.

ARTICLE X

SECTIONS AND DIVISIONS

SECTION 1. Local Sections may be established by the Executive Committee on receipt of a written request to that effect signed by twenty Active or Corporate Members of the Association, residing in the territory within which the Local Section is desired.

SECTION 2. National Divisions consisting of Engineers, Superintendents, Chemists and Bacteriologists, Accountants or other classes of persons included in the membership of the Association, may be established by the Executive Committee on the request of thirty members. Any member of the Association may register in any National Division of the Association in which he is interested.

SECTION 3. Such Sections and Divisions, which shall consist only of members of this Association in good standing, shall elect their own officers and committees, subject to confirmation by the Secretary of the Association as to their standing in the Association, and may make any rules for their government not inconsistent with the Constitution and By-Laws of the Association, but these rules must first be approved by the Executive Committee.

SECTION 4. Each Local Section as soon as established, and after its rules have been approved by the Executive Committee, may with the approval of the Finance Committee, annually receive from the Treasurer of the Association, for local use, not more than twenty-five per cent of the annual dues paid to the Association by the members of the said Local Section as shown by the books of the Association on the first day of November of each year; except that in no case shall the total of all moneys received by any Local Section for any one fiscal year exceed the sum of three hundred dollars, and except that Local Sections with small memberships, where the allotted twenty-five per cent of the annual dues paid to the Association by the members of the said Local Section does not amount to one hundred dollars, such Local Sections shall be entitled to receive from the Treasurer of the Association, for local use, not more than one hundred dollars in any one fiscal year.

Each National Division when established, and its rules and constitution have been approved by the Executive Committee, may, with the approval of the Finance Committee, annually receive from the Treasurer of the Association a sum not exceeding one hundred dollars, for Division Expenses.

The Treasurer of each Local Section or National Division shall forward to the Secretary of the Association his application endorsed by the presiding officer of the Section or Division for such portions of the said sums above specified as may be needed, and upon receipt of such application the Secretary shall request the Finance Committee to authorize the Treasurer of the Association to pay such sums to the Treasurer of the Section or Division. These moneys may be used by the Section or Division only in payment of necessary operating expenses, such as printing, stationery, postage, rent and care of meeting room, light, fuel, stenographer, and stereopticon operator services at meetings, etc.

At the end of each fiscal year the Treasurer of each Section and Division shall submit a certified copy of his accounts to the Secretary of the Association, the same being itemized and showing the balance on hand of funds received from the Association. This balance shall be returned to the Secretary of the Association or shall be charged to the Section or Division as part of its quota for the following year.

Section 5. The presiding officer of each Section and each Division shall be an Honorary Vice-President of the Association.

Section 6. Any Section may be dissolved by the Executive Committee for good and sufficient reasons.

ARTICLE XI

General

Section 1. Any member may, with the concurrence of the presiding officer, admit friends to the meetings of the Association, but such persons shall not take part in the discussions without the consent of the convention; and the privilege of the floor can only be granted to a non-member by unanimous consent.

Section 2. The Secretary shall send notice to all members of the Association at least fifteen days before the annual convention, giving the titles of papers to be read and mentioning any special business to be considered at said convention.

ARTICLE XII

Amendments

Section 1. All proposed amendments to the Constitution shall be submitted in writing to the Executive Committee which at its discretion may bring them before the next Annual Convention of the Association, but the Executive Committee must do so on the request in writing of five members of the Association.

Section 2. To pass an amendment to the Constitution, an affirmative vote of two-thirds of the members present and voting at said convention shall be required.

PAST PRESIDENTS

*Col. J. T. Foster, Chicago, Ill.	1881–1882
*Col. J. T. Foster, Chicago, Ill.	1882–1883
*J. G. Briggs, Terre Haute, Ind.	1883–1884
*L. H. Gardner, New Orleans, La.	1884–1885
*Peter Milne, Brooklyn, N. Y.	1885–1886
†B. F. Jones, Kansas City, Mo.	1886–1887
*J. T. Fanning, Minneapolis, Minn.	1887–1888
†A. N. Denman, Des Moines, Ia.	1888–1889
*J. H. Decker, Salina, Kans.	1889–1890
†William B. Bull, Quincy, Ill.	1890–1891
J. M. Diven, Troy, N. Y.	1891–1892
G. H. Benzenberg, Milwaukee, Wis.	1892–1893
James P. Donahue, Davenport, Ia.	1893–1894
*William Ryle, Paterson, N. J.	1894–1895
*W. G. Richards, Atlanta, Ga.	1895–1896
*F. A. W. Davis, Indianapolis, Ind.	1896–1897
John Caulfield, St. Paul, Minn.	1897–1898
*Joseph A. Bond, Wilmington, Del.	1898–1899
R. M. Clayton, Atlanta, Ga.	1899–1900
†C. E. Bolling, Richmond, Va.	1900–1901
*William R. Hill, New York, N. Y.	1901–1902
*C. H. Campbell, Charlotte, N. C.	1902–1903
†L. N. Case, Duluth, Minn.	1903–1904
Morris R. Sherrerd, Newark, N. J.	1904–1905
†Benjamin C. Adkins, St. Louis, Mo.	1905–1906
Dabney H. Maury, Chicago, Ill.	1906–1907
George H. Felix, Reading, Pa.	1907–1908
D. W. French, Weehawken, N. J.	1908–1909
Dr. William P. Mason, Troy, N. Y.	1909–1910
John W. Alvord, Chicago, Ill.	1910–1911
Alexander Milne, St. Catharines, Ont.	1911–1912
Dow R. Gwinn, Terre Haute, Ind.	1912–1913
Robert J. Thomas, Lowell, Mass.	1913–1914
George G. Earl, New Orleans, La.	1914–1915
Nicholas S. Hill, Jr., New York, N. Y.	1915–1916
Leonard Metcalf, Boston, Mass.	1916–1917
Theodore A. Leisen, Omaha, Neb.	1917–1918
Charles R. Henderson, Davenport, Ia.	1918–1919
Carleton E. Davis, Indianapolis, Ind.	1919–1920
Beekman C. Little, Rochester, N. Y.	1920–1921
Edward Bartow, Iowa City, Ia.	1921–1922
W. S. Cramer, Lexington, Ky.	1922–1923
George W. Fuller, New York, N. Y.	1923–1924

* Deceased.

† Not now a member of the Association.

CONVENTIONS

	Place	Date	President
1	St. Louis, Mo.	March 29, 1881	J. T. Foster
2	Columbus, Ohio	March 14–16, 1882	J. T. Foster
3	Buffalo, N. Y.	May 15–17, 1883	J. T. Foster
4	Cincinnati, Ohio	April 15–17, 1884	J. G. Briggs
5	Boston, Mass.	April 21–23, 1885	L. H. Gardner
6	Denver, Colo.	June 23–25, 1886	Peter Milne, Jr.
7	Minneapolis, Minn.	July 13–15, 1887	B. F. Jones
8	Cleveland, Ohio	April 17–19, 1888	J. T. Fanning
9	Louisville, Ky.	April 16–18, 1889	A. N. Denman
10	Chicago, Ill.	May 20–24, 1890	J. H. Decker
11	Philadelphia, Pa.	May 14–17, 1891	Wm. B. Bull
12	New York, N. Y.	May 17–19, 1892	J. M. Diven
13	Milwaukee, Wis.	September 5–9, 1893	G. H. Benzenberg
14	Minneapolis, Minn.	August 21–23, 1894	James P. Donahue
15	Atlanta, Ga.	May 28–30, 1895	William Ryle
16	Indianapolis, Ind.	May 26–28, 1896	W. G. Richards
17	Denver, Colo.	June 8–10, 1897	F. A. W. Davis
18	Buffalo, N. Y.	June 14–18, 1898	John Caulfield
19	Columbus, Ohio	May 16–19, 1899	Joseph A. Bond
20	Richmond, Va.	May 15–18, 1900	R. M. Clayton
21	New York, N. Y.	June 17–22, 1901	Charles E. Bolling
22	Chicago, Ill.	June 10–13, 1902	Wm. R. Hill
23	Detroit, Mich.	June 23–26, 1903	Chas. H. Campbell
24	St. Louis, Mo.	June 6–11, 1904	L. N. Case
25	West Baden, Ind.	May 9–12, 1905	Morris R. Sherrerd
26	Boston, Mass.	June 26–30, 1906	Benjamin C. Adkins
27	Toronto, Ont.	June 17–21, 1907	Dabney H. Maury
28	Washington, D. C.	May 11–16, 1908	George H. Felix
29	Milwaukee, Wis.	June 7–12, 1909	D. W. French
30	New Orleans, La.	April 25–29, 1910	Wm. P. Mason
31	Rochester, N. Y.	June 5–10, 1911	John W. Alvord
32	Louisville, Ky.	June 3–7, 1912	Alexander Milne
33	Minneapolis, Minn.	June 23–27, 1913	Dow R. Gwinn
34	Philadelphia, Pa.	May 11–15, 1914	Robert J. Thomas
35	Cincinnati, Ohio	May 10–14, 1915	George G. Earl
36	New York, N. Y.	June 5–9, 1916	Nicholas S. Hill, Jr.
37	Richmond, Va.	May 7–11, 1917	Leonard Metcalf
38	St. Louis, Mo.	May 13–17, 1918	Theodore A. Leisen
39	Buffalo, N. Y.	June 9–13, 1919	Charles R. Henderson
40	Montreal, Que.	June 21–25, 1920	Carleton E. Davis
41	Cleveland, Ohio	June 6–10, 1921	Beekman C. Little
42	Philadelphia, Pa.	May 15–19, 1922	Edward Bartow
43	Detroit, Mich.	June 21–25, 1923	W. S. Cramer
44	New York, N. Y.	May 19–23, 1924	George W. Fuller

LIST OF OFFICERS 1924–1925

President

Frank C. Jordan, Secretary of Indianapolis Water Company, 113 Monument Circle, Indianapolis, Ind.

Vice-President

Harry F. Huy, General Manager, Western New York Water Company, 704 Electric Bldg., Buffalo, N. Y.

Treasurer

William W. Brush, Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, Municipal Bldg., New York, N. Y.

Secretary Emeritus

J. M. Diven, Superintendent Water Department, Troy, N. Y.

Secretary

W. M. Niesley, Room 1013, 170 Broadway, New York, N. Y.

Editor

Abel Wolman, 16 West Saratoga St., Baltimore, Md.

Trustees

Term Expiring 1925

Joseph W. Ellms, Cons. Engr., 1263 Cook Ave., Lakewood, Ohio.

George W. Batchelder, Water Commissioner, 19 City Hall, Worcester, Mass.

Alexander Milne, Superintendent Water Works, St. Catharines, Ont., Can.

Term Expiring 1926

Edward E. Wall, Water Commissioner, 312 City Hall, St. Louis, Mo.

Charles R. Bettes, Chief Engineer, Queens County Water Co., Far Rockaway, L. I., N. Y.

James E. Gibson, Manager and Engineer, Water Department, 14 George St., Charleston, S. C.

Term Expiring 1927

J. Arthur Jensen, Supervisor, Water Works Department, Minneapolis, Minn.

Edgar M. Hoopes, Jr., Water Commissioner, Box 895, Wilmington, Del.

Fred Morse Randlett, Chief Engineer, Water Bureau, City Hall, Portland, Ore.

Executive Committee

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GEORGE W. BATCHELDER
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WILLIAM W. BRUSH
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William W. Brush, Dept. of Water Supply, Gas and Electricity Municipal Bldg., New York, N. Y.
Charles R. Bettes, Queens County Water Co., Far Rockaway, L. I., N. Y.

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Abel Wolman, Editor, 16 W. Saratoga St., Baltimore, Md.

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Thomas L. Amiss, Supt. Water and Sewerage, Shreveport, La.
Lewis I. Birdsall, General Chemical Co., 112 W. Adams St., Chicago, Ill.

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Paul Norcross, 1404 Candler Bldg., Atlanta, Ga.
C. N. Avery, Commissioner, Water, Light and Power, Austin, Tex.
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Dennis F. O'Brien, East Orange, N. J.
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S. Walter Ackerman, City Manager, Watertown, N. Y.
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STANDARD FORM OF CONTRACT

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Theodore A. Leisen, Omaha, Neb.
John N. Chester, Union Bank Bldg., Pittsburgh, Pa.
Henry P. Bohmann, Supt. Water Works, Milwaukee, Wis.
Charles R. Gow, West Roxbury, Mass.
Carleton E. Davis, Indianapolis Water Co., Indianapolis, Ind.
Thomas H. Wiggin, 50 Church St., New York, N. Y.
G. A. Elliott, 375 Sutter St., San Francisco, Calif.
John M. Goodell, Secretary. 106 Lorraine Ave., Upper Montclair, N. J.

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SPONSORSHIP OF A. W. W. A. FOR REVISION OF CAST IRON PIPE STANDARDS

Frank A. Barbour, 1120 Tremont Temple, Boston, Mass., Representative on Committee of Sponsor Organizations under American Engineering Standards Committee.

SPONSORSHIP OF A. W. W. A. FOR STANDARDIZATION OF FIRE HOSE COUPLING THREAD

Dennis F. O'Brien, A. P. Smith Mfg. Co., East Orange, N. J., Representative on Committee of Sponsor Organizations under American Engineering Standards Committee.

LIST OF PERSONNEL OF STANDARDS COMMITTEES AND COUNCIL ON STANDARDIZATION

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Frank A. Barbour, 1120 Tremont Bldg., Boston, Mass.

W. S. Cramer, Lexington Water Co., Lexington, Ky.
W. W. DeBerard, Old Colony Bldg., Chicago, Ill.
Edward E. Wall, 312 City Hall, St. Louis, Mo.
Malcolm Pirnie, Secretary, 25 West 43d Street, N. Y. C.

Standards Committees:

Committee No. 1—Standard Methods of Water Analysis

Jack J. Hinman, Jr., Chairman, Iowa State University, Iowa City, Iowa.

(a) Chemical

R. C. Bardwell, 3211 Hanover Ave., Richmond, Va.
Lewis I. Birdsall, 112 W. Adams St., Chicago, Ill.
A. M. Buswell, University of Illinois, Urbana, Ill.
Harry W. Clark, State Dept. of Health, Rm. 541, State House, Boston, Mass.
William Mansfield Clark, Hygienic Laboratories, U. S. Public Health Service, 25th & E Sts., Washington, D. C.
John R. Baylis, Baltimore Filtration Plant, Baltimore, Md.

(b) Bacteriological

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N. J. Howard, Dept. Public Health, Toronto, Ont.
Harry E. Jordan, 113 Monument Circle, Indianapolis, Ind.
Max Levine, Associate Professor of Bacteriology, Iowa State College, Ames, Iowa.
MacHarvey McCrady, Province of Quebec Board of Health, 56 Notre Dame, East Montreal, Quebec
Dale L. Maffitt, Des Moines Water Plant, Des Moines, Ia.
Floyd W. Mohlman, 39th St., Lake Michigan, Chicago, Ill.
J. W. Bugbee, Dept. Pub. Works, City Hall, Providence, R. I.

Committee No. 2—Work completed.

Committee No. 3—Practicable Loadings for Purification Processes

Seth M. Van Loan, Chairman, 796 City Hall, Philadelphia, Pa.
Wellington Donaldson, 170 Broadway, New York City.
C. M. Daily, St. Louis Water Dept. St. Louis, Mo.
F. W. Green, Montclaire Water Co. Little Falls, N. J.
Harry F. Ferguson, Chief Sanitary Engr., Dept. Public Health, Springfield, Ill.
C. G. Gillespie, 4136, Manila Ave., Oakland, Cal.
Albert H. Jewell, 405 Hall Bldg., 9th & Walnut Sts., Kansas City, Mo.
Winfield S. Mahlie, Filtn. Plant, Fort Worth, Texas.
Richard Messer, Chief Engr., State Dept. of Health, Richmond, Va.
Frank Raab, 3940 Harriet Ave., Minneapolis, Minn.
E. H. Read, Johns Hopkins University, Baltimore, Md.
H. W. Streeter, San. Engr., Public Health Service, 3rd & Kilgour Sts., Cincinnati, O.
F. Holman Waring, Asst. Engr., State Bd. of Health, Columbus, O.
G. E. Willcomb, 12 So. Lyons Ave., Albany, N. Y.

Committee No. 4.—Physical Chemistry in Relation to Water Purification

Robert Spurr Weston, Chairman, 14 Beacon St., Boston, Mass.
John R. Baylis, Hillen Road, Baltimore, Md.

A. M. Buswell, University of Illinois, Urbana, Ill.
Linn H. Enslow, 110 Capitol St., Richmond, Va.
Frank Hannan, Chst., Toronto Filtration Plant, Toronto, Ont.
Charles P. Hoover, Chemist Filtration Plant, Columbus, O.
H. E. Jordan, 113 Monument Circle, Indianapolis, Ind.
E. J. Rowe, Supt. Water and Light Dept., Wellsville, N. Y.
M. C. Whipple, 112 Pierce Hall, Cambridge, Mass.

Committee No. 5—Watershed Protection

H. E. Moses, Chairman, 904, N. 2nd St., Harrisburg, Pa.
Theodore DeL. Coffin, Katonah, N. Y.
F. A. Dallyn, Spadina House, Spadina Cres., Toronto, Ont.
John A. Foulks, Chief Engr., Division of Water, Newark, N. J.
Samuel A. Greeley, 39 W. Adams St., Chicago, Ill.
W. C. Hawley, 712 South Ave., Wilkinsburg, Pa.
F. T. Kemble, 238 Main St., New Rochelle, N. Y.
William V. Locke, Metrop. Water Board, Boston, Mass.
Fred M. Randlett, Chf. Engr., Water Bureau, Portland, Ore.
S. P. Senior, Vice-Pres., Bridgeport Hydraulic Co., Bridgeport, Conn.

Committee No. 6—Industrial Wastes in Relation to Water Supply

Almon L. Fales, Chairman, 14 Beacon St., Boston, Mass.
Wellington Donaldson, 170 Broadway, New York City.
C. A. Emerson, Jr., 1001 Chestnut St., Philadelphia, Pa.
L. A. Geupel, San. Engr., Health Dept., Indianapolis, Ind.
C. G. Gillespie, 4136 Manila Ave., Oakland, Cal.
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Clarence R. Knowles, 6627 Woodlawn Ave., Chicago, Ill.
F. W. Mohlman, Sanitary Dist., 39th St. & Lake Michigan, Chicago.
James A. Newlands, 11 Laurel St., Hartford, Conn.
C. A. Spencer, 208 Couler Bldg., Greensburg, Pa.

Committee No. 7—Pumping Station Betterments

Leonard A. Day, Chairman, 34 East Grand Blvd., St. Louis, Mo.
John N. Chester, Union Bank Bldg., Pittsburgh, Pa.
F. G. Cunningham, 879 North Parkway, Memphis, Tenn.
L. R. Howson, Hartford Bldg., Chicago, Ill.
L. A. Quayle, Water Department, Cleveland, O.

Committee No. 8—Physical Standards for Distribution System

G. Gale Dixon, Chairman, 102 E. Mill St., Akron, O.
G. W. Booth, Chief Engr., Natl. Bd. Fire Underwriters, 76 William St., New York City.
L. Chivvis, Engr. of Distbn. Water Dept., St. Louis, Mo.
Clarence Goldsmith, Asst. Chief Engr. Nat. Bd. of Fire Underwriters, 209 W. Jackson Boulevard, Chicago, Ill.
A. S. Holway, Holway Engineering Co., Tulsa, Okla.
J. Arthur Jensen, Supt. Water Works Dept., Minneapolis, Minn.
E. E. Lanpher, Dist. Dept., Pittsburgh, Pa.
W. E. MacDonald, 21 Fourth Ave., Ottawa, Canada

V. Bernard Siems, Asso. Civil Engr., Water Dept., Baltimore, Md.
W. Z. Smith, Genl. Mgr., Water Works, Atlanta, Ga.
John J. Laboon, Cons. Engr., Union Bank Bldg., Pittsburgh, Pa.

Committee No. 9—Standard Specifications for Cast Iron Pipe & Specials

Frank A. Barbour, Chairman, 1120 Tremont Bldg., Boston, Mass.
Walter Wood, President, Millville Water Co., Philadelphia, Pa.
Edward E. Wall, Water Commissioner, St. Louis, Mo.
N. F. S. Russell, 1421 Chestnut St., Philadelphia, Pa.
William C. Hawley, 712 South Ave., Wilkinsburg, Pa.
William W. Brush, 2455 Municipal Bldg., New York City.
Thomas H. Wiggin, 50 Church St., New York City.

Committee No. 10—Standardization of Services

J. M. Diven, Chairman, Water Dept., Troy, N. Y.
Bernard J. Bleistein, 143 Sterling St., Long Island City, N. Y.
George C. Bunker, P. O. Box 262, Ancon, Canal Zone.
James E. Gibson, 14 George St., Charleston, S. C.
R. E. Greenfield, State Water Survey, Urbana, Ill.
Chas. D. Howard, State Board of Health, Concord, N. H.
R. B. Morse, Chief Engr., Washington Suburban San. Dist., Hyattsville, Md.
George Read, Water Dept., Los Angeles, Cal.
M. C. Whipple, Harvard University, Cambridge, Mass.
Stephen deM. Gage, San. Engr., State Bd. of Health, Providence, R. I.

Committee No. 12—Testing of Water Works Materials and Supplies

Thomas H. Wiggin, Chairman, 50 Church St., New York City.
W. R. Conard, Savings Institution Bldg., Burlington, N. J.
August V. Graf, Chemist, Water Works, St. Louis, Mo.
C. P. Hoover, Filtration Plant, Columbus, Ohio
F. A. McInnes, Cons. Engr. 236 Bay State Road, Boston, Mass.
Richard Merriman, 600 Walnut St., Kansas City, Mo.
Thaddeus Merriman, Chf. Engr. Bd. Water Supply, Municipal Bldg., New York City.

Committee No. 13—Methods and Records of Water Waste Control

William W. Brush, Chairman, 2455 Municipal Bldg., New York City
George C. Andrews, Water Commissioner, Buffalo, N. Y.
Henry P. Bohmann, Supt. Water Works, Milwaukee, Wis.
Edward S. Cole, 50 Church St., New York City.
John Erickson, City Engineer, Chicago, Ill.
Charles S. Foreman, Supt. Water Works, Kansas City, Mo.

Committee No. 14—Committee on Meter Rates

Allen Hazen, Chairman, 25 West 43d St., New York City.
Isaac Walker, Secretary, Mgr. New Chester Water Co., 594 Drexel Bldg., Philadelphia, Pa.
Theodore A. Leisen, Gen. Mgr. Metro. Utilities Dist., 18th and Farnum Sts., Omaha, Nebr.
Burton Lowther, Supt. Water Works, Denver, Colo.
George N. Schoonmaker, Constn. Div., Water Dept., Toledo, O.

Committee No. 15—Practical Standards of Rules and Regulations of Relations Between Water Works and Consumers

Frank C. Jordan, Chairman, 113 Monument Circle, Indianapolis, Ind.
F. E. Beck, Consolidated Water Co., Utica, N. Y.
George W. Biggs, Jr., 50 Broad St., New York City.
G. A. Elliott, 1270 Sacramento St., San Francisco, Cal.
Geo. H. Fenkell, Cor. Jefferson and Randolph Sts., Detroit, Mich.
D. W. French, Supt. Hackensack Water Co., Weehawken, N. J.
Charles R. Henderson, Manager Water Co., Davenport, Ia.
Henry B. Morgan, Mgr., Peoria W. W. Co., 143 No. Jefferson Ave., Peoria, Ill.
C. M. Saville, 53 North Beacon St., Hartford, Conn.

Committee No. 16—Essential Data for Water Records and Reports

(a) Municipal Plants

George H. Fenkell, Chairman, Supt. Bd. Water Comnrs., Detroit, Mich.
L. M. Anderson, Controller of the Bd. of Public Service Commissions, Los Angeles, Cal.
Robert M. Anderson, Water Department, Tulsa, Okla.
G. W. Batchelder, 19 City Hall, Worcester, Mass.
Charles S. Denman, Manager, Water Co., Des Moines, Ia.
D. C. Grobbel, Asst. Secty. Bd. Water Commrs, Detroit, Mich.
Frank P. Larmon, Chf. Engr., Metrop. Water Dist., Omaha, Neb.
W. J. McCourt, Water Dept., City Hall, Chicago, Ill.

(b) Privately Owned Plants

John N. Chester, Chairman, Union Bank Bldg., Pittsburg, Pa.
F. E. Beck, Chief Engr., Consolidated Water Co., Utica, N. Y.
Dow R. Gwinn, Pres. Water Co., Terre Haute, Ind.
Allen W. Cuddeback, Supt. Passaic Water Co., Paterson, N. J.
Robert J. Harding, V. Pres. Water Co., San Antonio, Tex.

Committee No. 17—Steel Pipe Lines

Theodore A. Leisen, Chairman, Gen. Mgr., Metro. Utilities Dist., 18th & Farnum Sts., Omaha, Neb.
Allen W. Cuddeback, Supt. Passaic Water Co., 158 Ellison St., Paterson, N. J.
G. Gale Dixon, Finance Bldg., Cleveland, O.
Edgar G. Ritchie, Melbourne and Metropolitan Board of Works, Melbourne, Australia.
H. Seaver Jones, 50 Church St., New York City.
Leonard Metcalf, 14 Beacon St., Boston, Mass.
Walter E. Spear, Bd. of Water Supply, Municipal Bldg., New York City.
George Wilhelm, Chief Engr., East Bay Water Co., Oakland, Cal.

Committee No. 18—Filter Sand, Testing and Recording

Paul Hansen, Chairman, 39 W. Adams St., Chicago, Ill.
Maurice Z. Bair, Chief Engr., State Bd. of Health, Little Rock, Ark.
George G. Catlett, Sanitary Engr., State Board of Health, Raleigh, N. C.
Edward S. Chase, 14 Beacon St., Boston, Mass.

Harry F. Ferguson, Chief Engr., State Dept. of Health, Springfield, Ill.

George C. Habermeyer, 57 Chemistry Bldg., Urbana, Ill.

Harry N. Jenks, 1560 LeRoy Ave., Berkeley, Cal.

P. B. Streander, Chief Eng. Roberts Filter Co., Darby, Pa.

James E. Williamson, 39 Cortlandt St., N. Y.

Committee No. 19—Boiler Feed Water Studies

S. T. Powell, Chairman, Chemical Engineer, Baltimore, Md.

Edward Bartow, University of Iowa, Iowa City, Iowa.

A. G. Christie, Johns Hopkins University, Baltimore, Md.

Wellington Donaldson, Fuller & McClintock, New York City, N. Y.

V. M. Frost, Newark Public Service Corporation, Newark, N. J.

C. P. Van Gundy, Baltimore and Ohio Railroad, Baltimore, Md.

C. F. Hirshfeld, Detroit Edison Co., Detroit, Mich.

A. R. Knowles, Illinois Central Railroad, Chicago, Ill.

A. L. Penniman, Consolidated Gas, Electric Light and Power Company, Baltimore, Md.

George C. Whipple, Harvard University, Cambridge, Mass.

List of Abstractors

Frank Hannan, *Chief*, 181 Willow Avenue, Toronto, Ont., Canada

Bachmann, Frank, c/o Dorr Co., 38 So. Dearborn St., Chicago, Ill.

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Bardwell, R. C., Supt. Water Supply, C. and O. Railroad, 3211 Hanover Ave., Richmond, Va.

Baylis, John R., Lake Montebello, Hillen Road, Baltimore, Md.

Birdsall, Lewis, I., c/o General Chemical Co., 112 West Adams St., Chicago, Ill.

Blohm, Arthur, W. P., State Department of Health, 2206 Walbrook Ave., Baltimore, Md.

Bunker, George C., P. O. Box 262, Ancon, C. Z.

Buswell, A. M., Chief, State Water Survey Division, Urbana, Ill.

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French, Dudley K., Chemist, Dearborn Chemical Co., 2005 McCormick Bldg., Chicago, Ill.

Hinman, Jack J., Jr., P. O. Box 313, Iowa City, Iowa

Hoover, Charles P. Chemist, Filtration Plant, Columbus, Ohio.

Howard, N. J., Bacteriologist in Charge, Filtration Plant Laboratory, Centre Island, Toronto, Ont., Can.

Jordan, Harry E., 113 Monument Circle, Indianapolis, Ind.

McCrady, MacHarvey, 59 Notre Dame, East, Montreat, Can.
Mendelsohn, Isador W., U. S. Public Health Service, 420 Call Bldg., San Francisco, Cal.
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Pincus, Sol, 255 W. 108th St., New York, N. Y.
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Thompson, Rudolph E., Filtration Plant, 596 Milverton Blvd., Toronto, Ont., Can.

List of Publications Abstracted

Affiliated Engineering Societies of Minnesota—Bulletin.
American Chemical Society—Journal.
American City.
American Electro-Chemical Society—Proceedings.
American Forestry.
American Medical Association—Annual Index.
American Medical Association—Journal.
American Meteorological Society—Publications.
American Public Health Association—Journal.
Americn Railway Engineering Association—Journal.
American Society of Civil Engineers—Proceedings.
American Society for Municipal Improvements—Proceedings.
Board of Fire Underwriters—Reports.
Boston Society of Civil Engineers—Journal.
Canada–Department of the Interior—Water Supply Bulletins.
Canadian Engineer.
Canadian Water Works Association—Journal.
City Reports (Misc.)
Cleveland Engineering Society—Journal.
Concrete.
Connecticut Association of Civil Engineers—Proceedings.
Dayton Engineers' Club—Publications.
Engineering Association of the South—Proceedings.
Engineering and Contracting.
Engineering News—Record.
Engineers' Club of Philadelphia—Journal.
Engineers of St. Louis—Journal.
Engineers' Institute of Canada—Journal.
Engineers' Society of Western Pennsylvania—Proceedings.
Fire and Water Engineering.
Franklin Institute—Journal.
Illinois Society of Engineers—Reports.
Illinois State Water Survey—Bulletins.

Indiana Engineering Societies—Proceedings.
Indiana Sanitary and Water Supply Association—Proceedings.
Ingenieria Internacional (Published in New York).
Iowa Engineering Societies—Proceedings.
Journal of Bacteriology.
Journal of Biological Chemistry.
Louisiana Engineering Society—Proceedings.
Mechanical Engineering (Jour. Am. Soc. M. E.)
Missouri Water Works Association—Journal.
Monthly Weather Review (U. S. Weather Bureau.)
Municipal and County Engineering.
New England Water Works Association—Journal.
Ohio Engineering Societies—Proceedings.
Ohio Water Works Association—Proceedings.
Pennsylvania Water Works Association—Proceedings.
Power.
Public Health Engineering Abstracts (U. S.).
Public Utility Reports.
Public Works.
Railway Age.
Railway Maintenance Engineer.
Railway Mechanical Engineer.
Railway Review.
Scientific Lubrication.
Southwestern Water Works Association—Journal.
State Boards of Health—Reports and Bulletins (Misc.)
U. S. Bureau of Agriculture—Bulletins and Circulars.
U. S. Bureau of the Census—Statistics.
U. S. Bureau of Mines—Bulletins, Circulars and Technical Papers.
U. S. Bureau of Standards—Bulletins, Circulars, Technical Papers, etc.
U. S. Dept. of Agriculture—Bulletins and Circulars.
U. S. Public Health Service—Reports, Bulletins and Reprints.
U. S. Geological Survey—Water Supply Papers, Bulletins and Circulars.
University Bulletins (Misc.)
Utah Society of Engineers—Proceedings.
Western Society of Engineers—Journal.

LIST OF MEMBERS

OCTOBER 1, 1924

HONORARY MEMBERS

BENZENBERG, G. H. Cons. Engr., Retired, 1018 Wells Bldg., Milwaukee, Wis.	Apr. 17, 1888
CAULFIELD, JOHN. Mangr. Bismarck Water Supply Co., Bismarck, N. Dak.	July 14, 1887
DIVEN, J. M. Supt., Water Dept., Troy, N. Y.	Apr. 16, 1884
FITZGERALD, DESMOND. Cons. Engr., 410 Washington St., Brookline, Mass.	June 24, 1923
HERSCHEL, CLEMENS. 2 Wall St., New York, N. Y.	May 20, 1924
HOLMAN, M. L. 4385 Forest Park Blvd., St. Louis, Mo.	Mar. 21, 1881
HOUSTON, SIR ALEXANDER C. Dctr. Wtr. Exmn. Met. Wtr. Bd., 20 Nottingham Place, London, England	June 24, 1923
KEELER, H. E. The Rookery, Room 633, Chicago, Ill.	July 14, 1887
MULHOLLAND, WILLIAM. Chf. Engr. Dpt. Pub. Svce., 645 So. Olive St., Los Angeles, Cal.	June 24, 1923
NAKAJIMA, Y. Hongo Hayaschicho, 185, Tokyo, Japan	July 14, 1887
PURDY, J. H. c/o Amer. Water Wks. & Electric Co., 50 Broad St., New York, N. Y.	May 27, 1896

ACTIVE MEMBERS

ABBOTT, CARROLL B. Prest., Wtr. Wks. Sup. Co., 536 Call Building, San Francisco, Calif.	May 24, 1922
ABBOTT, C. E. Mgr., Water Works, Tuscaloosa, Ala.	June 15, 1916
ABBOTT, G. H. Treasr. and Supt., Southbridge Water Supply Co., Southbridge, Mass.	May 17, 1912
ABSHER, C. W. Supt., Filtration, c/o Water & Light Dept., Mount Airy, N. C.	Apr. 23, 1924
ACKERMAN, J. WALTER. City Manager, Watertown, N. Y.	Feb. 2, 1910
ADAMS, ALTON D. 120 Prospect St., Wellesley, Mass.	Sept. 30, 1912
ADAMS, HENRY. Cons. Engr., 1263-69 Calvert Building, Baltimore, Md.	Apr. 27, 1914
ADAMS, J. C. Amer. Wtr. Wks. and El. Co., 50 Broad St., New York, N. Y.	Mar. 31, 1921
AERYNS, ALBERT NELSON, C.E. 716 Greenwood Ave., Brooklyn, N. Y.	Jan. 18, 1915
AHEARN, BERTRAM J., C.E. 920 Liberty St., Peekskill, N. Y.	Mar. 25, 1924
AHERN, J. F. Fairbanks, Morse & Co., 1765 Post St., Jacksonville, Fla.	Apr. 3, 1922
ALEXANDER, R. C. Mgr., Water Co., Centerville, Ia.	July 20, 1920
ALLEMAN, DR. GELLERT. Prof. of Chemistry, Swarthmore, Pa.	June 21, 1921
ALLEN, C. D. 50 Lombard St., Toronto, Ont., Canada	Apr. 29, 1924
ALLEN, CLAYTON M. Filter Operator, 111 West State St., Wellsville, N. Y.	May 24, 1922
ALLEN, S. L. Georgetown, Ky.	Jan. 19, 1924
ALLEN, THOMAS H. 1430 Bank of Commerce Bldg., Memphis, Tenn.	Dec. 20, 1923
ALLEN, WILLIAM JOHN. Chf. Engr. and Bacteriologist, 329 Cory Ave., Waukegan, Ill.	Jan. 17, 1915

Allin, T. D., C. E. 303 Kendall Bldg., Pasadena, Cal...... Mar. 28, 1910
Allison, James E. 1017 Olive St., St. Louis, Mo............ Feb. 17, 1913
Alpers, Frank H. Supt. Water Co., Cimarron, N. M....... Oct. 14, 1919
Alvord, John W. Cons. Engr., 1417-18 Hartford Bldg., Chicago, Ill.. Apr. 3, 1899
Ames, Clarence F. Supt. Water Works, Norwich, N. Y..... Mar. 30, 1918
Ames, Jeremiah L., Filtration Division, Porter Avenue Station, Bureau Water, Buffalo, N. Y.................. Nov. 28, 1922
Amiss, Thomas L. Supt. Water and Sewerage, Shreveport, La. May 14, 1918
Amsbary, F. C. Mgr. Water Co., Champaign, Ill........... June 8, 1909
Anderson, Robert M. Prof. Engineering Practice, Stevens Institute, Hoboken, N. J............................ Dec. 22, 1916
Andrews, George C. Water Commissioner, 2 Municipal Building, Buffalo, N. Y............................. Feb. 28, 1917
Andrews, Lewis P. Manager, Secy. and Treas. Water Co., Sedalia, Mo.. Apr. 13, 1909
Andrews, Robert E. National Board Fire Underwriters, 205 Merchants Exchange Bldg., San Francisco, Cal..... June 14, 1913
Angus, Robert W. Prof. of Mechanical Eng., University of Toronto, Toronto, Canada.......................... Feb. 5, 1917
Ankener, Richard. 140-12th Avenue, Long Island City, N.Y.. Oct. 14, 1922
Anthony, Chas. Genl. Mgr., Water Co., Cassilla Correo 149, Bahia Blanca, Argentine Republic, S. A........... June 29, 1909
Applebaum, Samuel Bernard, C.E. Sanitary Engineer, 78 Stephenson Blvd., New Rochelle, N. Y............... Apr. 24, 1916
Archer, Elmer T. Cons. Engr., New England Building, Kansas City, Mo....................................... May 14, 1918
Archibald, J. G. Supt. Water Works System, Woodstock, Ont.. Feb. 10, 1921
Armstrong, James W. Filtn. Engr. City Water Dept., Lake Montebello, Hillen Road, Baltimore, Md............... Mar. 12, 1910
Armstrong, Roger W. 172 Clinton St., Brooklyn, N. Y.... Apr. 8, 1916
Atkinson, Asher. City Engr., 49 Mine St., New Brunswick, N. J.. Mar. 27, 1922
Atkinson, T. R. Consulting Engineer, Bismarck, N. D..... May 18, 1914
Attersall, Charles F. Supt., Water Works, Winchester, Ky.. June 7, 1910
Avery, Charles Needham. Commissioner, Water, Light & Power, Austin, Texas.................................. May 28, 1924
Avery, Elwood. Asst. Engr., P. S. Comn. Cmlth. of Penna., 84 North 17th St., Harrisburg, Pa.................... Feb. 28, 1922
Ayres, Louis E., C.E., B.S. Pr. Asst. G. S. Williams, Cons. Engr., Cornwell Building, Ann Arbor, Mich...... Nov. 16, 1916
Ayres, Thomas H. 905 Sherman Ave., South Bend, Ind..... June 20, 1913

Babbitt, Harold E. 204 Engineering Hall, Urbana, Ill...... June 4, 1915
Babcock, G. H. Supt. Water Works, East Rochester, N. Y... June 7, 1916
Bacharach, E. W. Pres., E. W. Bacharach and Co., 616-17 Rialto Bldg., Kansas City, Mo......................... Apr. 29, 1924
Bachmann, Frank. c/o Dorr Co., 38 S. Dearborn St., Chicago, Ill.. Feb. 4, 1915
Bahlman, Clarence. Chief Botst., Cincinnati Filtration Plant, California, O.................................. Feb. 7, 1922
Bailey, John G. Supt. Water Distbn., Engr. Bldg., Main and Orange Sts., Jacksonville, Fla..................... Feb. 28, 1921
Bain, Ernest B. Supt., City Water Dept., Raleigh, N. C.... May 14, 1909
Bair, Maurice Z. Chf. Engr., State Board of Health, Capitol Bldg., Little Rock, Ark............................ Apr. 15, 1915

BAITY, H. G. Asst. Engr., Bureau San. Engr. & Inspec., State Board of Health, Raleigh, N. C.	May 15, 1923
BAKER, CLARENCE M. State Bd. of Hlth., Madison, Wis.	Oct. 4, 1915
BAKER, HAROLD WALLACE, Commissioner of Public Works, Rochester, N. Y.	Jan. 31, 1922
BAKER, M. N. Assoc. Editor, Engineering News-Record, 10th Ave. at 36th St., New York, N. Y.	June 24, 1903
BALDWIN, F. O. Supervisor, Water Purification Plt., 2710 West Grace St., Richmond, Va.	May 10, 1922
BALDWIN, FRED N. Supt., Water Works, Flint, Mich.	May 10, 1915
BALDWIN, HENRY DE FOREST. President Queens County Water Co., 25 Broadway, New York, N. Y.	Apr. 27, 1910
BALDWIN, HERBERT B., Chemist, Dept. of Health, 927 Broad St., Newark, N. J.	Mar. 27, 1919
BALDWIN, ROBERT T. Secretary, Chlorine Institute, Inc., 52 E. 41st St., New York, N. Y.	July 28, 1924
BALL, EDMUND BRUCE. "Braemar" Ayr, Scotland	Jan. 26, 1924
BALL, GEORGE W. Prest. I. C. Water Co., Paul-Helen Bldg. Iowa City, Ia.	Apr. 24, 1920
BALL, NORMAN Z. Asst. Engr., in Charge of Water & Sewers, Norfolk, Va.	Dec. 26, 1922
BALLOU, ARTHUR FRANCIS. Engr. Natl. Bd. of Fire Und., 76 William St., New York, N. Y.	Aug. 7, 1924
BAMPTON, SYDNEY WALLACE. Assistant Engineer, Bd. of Water Supply, Valhalla, N. Y.	Mar. 25, 1924
BANDY, WILLIAM B., C.E. 303 New Bern, Raleigh, N. C.	Dec. 12, 1921
BANK, WILLIAM G. Asst. Engr., Bureau of Water, Newark, N. J.	Dec. 16, 1919
BANKSON, ELLIS E., C.E. 1111 Union Bank Bldg., Pittsburgh, Pa.	July 27, 1922
BARBOUR, FRANK A. Hydraulic & Sanitary Engr., 1120 Tremont Bldg., Boston, Mass.	May 21, 1906
BARCLAY, W. E. Supt. Dept. Water and Elect., Aurora, Ill.	May 13, 1918
BARDWELL, R. C. Supt. Water Supply, C. & O. Railroad, 3211 Hanover Ave., Richmond, Va.	Nov. 3, 1916
BARKER, STANLEY T. Sr. Asst. Engr., State Dept. Pub. Hlth., Springfield, Ill.	Apr. 16, 1923
BARNARD, W. K. 704 Central Bldg., Los Angeles, Calif.	Oct. 31, 1923
BARNES, HOWARD P. Div. Engr., Board of Water Sup. N. Y. C., Croton-on-Hudson, N. Y.	Mar. 15, 1924
BARNES, T. HOWARD. Cons. Engr., 1637 Whitehall Building, New York, N. Y.	Dec. 14, 1914
BARNETT, A. G. Engineer, c/o Fuller & McClintock, 879 North Parkway, Memphis, Tenn.	Apr. 30, 1923
BARNETT, C. P. Consulting Engineer, Covington, Virginia	June 13, 1922
BARNHARD, P. Mgr., Mt. Carmel Public Utility Co., Mt. Carmel, Ill.	Oct. 19, 1914
BARNS, FREDERICK B. Engineer, c/o Nicholas S. Hill, 112 E. 19th St., New York, N. Y.	Mar. 14, 1922
BARR, WILLIAM M. Consulting Chemist, Union Pacific Systems, Omaha, Neb.	Feb. 9, 1917
BARRICK, M. J. 2007 Penn St., Harrisburg, Pa.	Feb. 16, 1924
BARRIER, EDWARD A. Glen Road, Wellesley Farms, Mass.	June 24, 1924
BARROWS, H. K. Cons. Engr., 6 Beacon St., Boston, Mass.	May 20, 1920
BARTLETT, N. EMORY. Natrona Water Co., 1000 Widener Building, Philadelphia, Pa.	June 7, 1909
BARTLETT, TERRELL. Cons. Engr., 612 Cacasieu Bldg., San Antonio, Tex.	June 8, 1923
BARTLEY, ROBERT, JR. Supt., Dept. Water & Sewers, Box 377, Asbury Park, N. J.	Mar. 8, 1924

Barton, Carl O. 8050 Second Ave., Detroit, Mich. Mar. 23, 1922
Bartow, Col. Edward. Chemistry Dept., State Univ. of Iowa, Iowa City, Ia. June 7, 1909
Bartram, George C. 1021 Elmwood Ave., Buffalo, N. Y. June 7, 1921
Bascom, G. R. c/o Barber Greene Co., 9 S. Clinton St., Chicago, Ill. Sept. 2, 1914
Bass, Frederick H. 429 Union St., Minneapolis, Minn. Apr. 2, 1909
Bassett, Carrol P., C.E. Summit, N. J. Oct. 14, 1909
Bassett, Charles K., M.E., Buffalo Meter Co., 2917 Main St., Buffalo, N. Y. June 13, 1921
Bassett, Geo. B., C.E. 691 W. Ferry St., Buffalo, N. Y. Apr. 12, 1909
Batchelder, George W. Water Commissioner, 19 City Hall, Worcester, Mass. Apr. 25, 1916
Bates, Prof. C. O. Chair of Chemistry, Coe College, Cedar Rapids, Ia. July 17, 1922
Bates, Ralph D. Chemist, Filter Plant, Clarksburg, W. Va. Feb. 10, 1921
Baton, Warren U. C. Chief Analyst, 528 S. Lang Ave., Pittsburgh, Pa. Apr. 9, 1909
Batt, John B. Supt. Water Works, North Tonawanda, N. Y. Apr. 24, 1919
Bauereisen, R. J. Engineering Contractor, 9 So. Clinton St., Chicago, Ill. Aug. 8, 1915
Baylis, John R. Prin. San. Chst., Baltimore Filtration Plant, Lake Montebello, Hillen Road, Baltimore, Md. Oct. 2, 1915
Bean, George L. Civil Engineer, 1729 N. 19th St., Philadelphia, Pa. Dec. 29, 1913
Beardsley, Joseph C. 1426 W. Third St., Rm. 303, Cleveland, Ohio. Apr. 15, 1909
Beck, F. E. Chf. Engr., Consolidated Water Co., Utica, N. Y. Apr. 20, 1915
Beck, H. A. Dctr. Pub. Svce., 201 Furnace St., Elyria, O. June 19, 1920
Bedell, Arthur S. State San. Engr., Salt Lake City, Utah. June 10, 1920
Bedell, James. Supt., Water Works, 10 Croton Ave., Ossining, N. Y. May 12, 1908
Beebe, Harwood. c/o Mr. W. S. Green, Mayor, Tryon, N. C. Dec. 8, 1923
Beers, William H. Box 116, Gatun, Canal Zone, Panama. Sept. 12, 1922
Beisel, N. J. Gen. Mgr., Pottsville Water Co., 221 South Center St., Pottsville, Pa. July 31, 1924
Belcher, Richard. Prest. Water Co., Marysville, Cal. Oct. 4, 1919
Bell, David V. Supt., Water Companies, U. P. R. R. Co., 325 N. Front St., Rock Springs, Wyo. May 14, 1909
Bell, H. K. Civil Engr., 372 Transylvania Park, Lexington, Ky. Jan. 16, 1924
Bemis, Edward W. Room 1605, 139 N. Clark St., Chicago, Ill. May 18, 1909
Benham, Webster L. Cons. Engr., 512 Gumbel Bldg., Kansas City, Mo. June 9, 1919
Bennett, C. G., M.E. State Public Utilities Comn., Springfield, Ill. Apr. 7, 1920
Bennett, J. S. Supt. Operation, Univ. of N. C., Chapel Hill, N. C. May 10, 1923
Benton, L. J. Supt. Water Dept., Fremont, N. C. Dec. 8, 1923
Berberich, Norbert M. Chemist, Huntington Water Corp., 1320 Fifth Ave., Huntington, W. Va. July 31, 1924
Bernhagen, Lewis O. City Hall, Beaumont, Tex. Mar. 6, 1917
Berry, Albert E. 31 Eighth Ave., Toronto, Ont. June 21, 1920
Berry, F. R. Engr. Am. W. W. & E. Co., 50 Broad St., New York, N. Y. Apr. 20, 1923
Berry, Fred D. Secty. Bd. Water Comrs., Hartford, Conn. Mar. 20, 1918
Besselievre, Edmund B., B.S. San. Engr., 300 Pitney Ave., Spring Lake, N. J. Oct. 7, 1919
Bettes, Charles R. Chief Engr. Queen Co. Water Works, Far Rockaway, L. I., N. Y. June 18, 1901

BEYER, ALBIN H., C.E. Assoc. Prof. in Civil Eng., Columbia University, New York, N. Y.	June 17, 1916
BIGGS, GEORGE W., Jr. Chf. Engr. Amer. Water Works and Elect. Co., 50 Broad St., New York, N. Y.	June 2, 1916
BILLINGS, LLOYD C. Supt. Filtn. Plant, 1247 Bemis St., S. E., Grand Rapids, Mich.	May 23, 1923
BIRD, BYRON. Prof. of Struc. Engr., Texas A. & M. College, Faculty Exchange Box 147, College Station, Tex.	July 31, 1924
BIRD, CYRUS R. The Pitometer Co., 906 Majestic Bldg., Detroit, Mich.	Mar. 16, 1922
BIRDSALL, LEWIS I. Care of General Chemical Company, 112 West Adams St., Chicago, Ill.	June 24, 1913
BIRKINBINE, CARL P. Hyd. Engr., Commercial Trust Bldg., Philadelphia, Pa.	June 2, 1916
BISER, D. BENTON. Asst. C. E., Water Dept. City Hall, Baltimore, Md.	Sept. 17, 1923
BISHOP, GUY H., C.E. Carolina Engineering Co., 412 Southern Bldg., Wilmington, N. C.	Sept. 26, 1921
BISHOP, WESLEY. Genl. Supt., Township of Moorestown Water Dept., Moorestown, N. J.	Mar. 29, 1916
BIZZELL, L. U. Supt. Water Works, Zebulon, N. C.	Dec. 8, 1923
BLACK, ERNEST B. Cons. Engr., Mutual Building, Kansas City, Mo.	June 24, 1913
BLACK, GURDON G. 3737 Washington Ave., St. Louis, Mo.	Feb. 13, 1915
BLAIN, CLAUD FRANCIS. Public Works Department, Sydney, N. S. W., Australia	Nov. 14, 1922
BLAIR, McCREA PARKER. 1133 Catherine St., Victoria, West, B. C.	Apr. 20, 1910
BLAIR, T. J., JR. 16 S. Main Ave., Weston, W. Va.	Apr. 23, 1924
BLANCHARD, R. K., M.E. Engr., Neptune Meter Co., 50 East 42nd St., New York, N. Y.	June 19, 1919
BLEISTEIN, BERNARD J. Asst. Engr., Dept. W. S. G. and E. of N. Y. City, 143 Sterling St., Brooklyn, N. Y.	Apr. 26, 1918
BLESSED, WILLIAM S. Mech. Engr., 800 Marquette Bldg., Detroit, Mich.	June 1, 1923
BLEVINS, WILLIAM H. Mgr., Water, Light & Power Co., Mt. Sterling, Ky.	Jan. 16, 1924
BLEW, MICHAEL JAMES. 8018 Germantown Ave., Chestnut Hill, Philadelphia, Pa.	Aug. 21, 1922
BLIVEN, CHARLES H. Supt. Norfolk City Water Dept., Norfolk, Va.	May 12, 1914
BLIVEN, GEO. H. Supt. Rochester and Lake Ont. Wtr. Co., 440 Powers Bldg., Rochester, N. Y.	Apr. 26, 1909
BLIVEN, M. HARVEY. Asst. Engr. Wtr., Dpt. Eastman Kodak, 71 Bellevue Drive, Rochester, N. Y.	Apr. 12, 1921
BLOCKIE, GEORGE D. Supt., Water Works, Hammond, Ind.	June 8, 1921
BLOHM, ARTHUR W. P. Engr. Asst. State Dept. Health, 2206 Walbrook Ave., Baltimore, Md.	Aug. 9, 1922
BLOMQUIST, H. F. Supt. City Water Works, Cedar Rapids, Ia.	May 13, 1917
BLOSSOM, FRANCIS. Engineer, 52 William St., New York, N. Y.	Apr. 9, 1906
BOARDMAN, W. H. Civil Engr., 426 Walnut St., Philadelphia, Pa.	Apr. 18, 1909
BODKIN, J. T. 404 N. Main St., Kokomo, Ind.	Mar. 19, 1924
BOEH, WM. H. 1041 Celestial St., Cincinnati, Ohio	Apr. 2, 1909
BOGERT, CLINTON L. Consulting Engineer, 30 Church St., Rm. 414, New York, N. Y.	Jan. 19, 1924
BOHMANN, HENRY P. Supt. Water Works, Milwaukee, Wis.	May 8, 1913

Bolton, James R. Supt. of Water Dept., City Hall, 20 Gerald Ave., Highland Park, Mich.	Mar. 25, 1924
Booker, Warren H. 121 Crescent Ave., Charlotte, N. C.	July 21, 1911
Booth, George W. 76 William St., New York, N. Y.	Feb. 2, 1924
Booth, L. M. Prest. Booth Chemical Co., P. O. Box 203, Elizabeth, N. J.	May 12, 1914
Booth, William Miller. Cons. Chem. Engr., 312 First Tr. & Dep. Bk. Bldg., Syracuse, N. Y.	June 8, 1909
Borden, Moro M. 310 Lees Ave., Collingswood, N. J.	June 5, 1912
Botten, H. H. Chief Engr., Washington Surv. & Rating Bur., P. O. Box 1818, Seattle, Wash.	Jan. 16, 1924
Bowe, Thomas Francis. Cons. Engr., 110 William St., New York, N. Y.	Feb. 9, 1920
Bowman, Abraham M. Supt. Public Utilities, Elmira, Ont.	Oct. 21, 1919
Bowne, Sidney B. Civil Engineer, Mineola, N. Y.	May 28, 1924
Boyle, Bryan J. Dpty., Wtr. Comnr. Bur. of Water, 2 Municipal Bldg., Buffalo, N. Y.	Mar. 16, 1922
Boyle, Edward Charles. 241 Jackson St., Trenton, N. J.	Apr. 12, 1916
Boyles, Marvin M. Supt., Water Dept., City Hall, Greensboro, N. C.	Sept. 26, 1921
Boynton, Perkins. Chst. in chge., New Chester Wtr. Wks., 115 W. Mowry St., Chester, Pa.	June 16, 1920
Bradbury, Edward Gatling. County Sanitary Engr., Court House, Columbus, O.	June 16, 1919
Bradley, E. B. City Bacteriologist, Lexington, Ky.	May 23, 1923
Bradley J. F. Chf. Engr. and Bact., R. F. D. 8, Valparaiso, Ind.	Feb. 10, 1921
Bragg, George H. 445 Sutter St., San Francisco, Cal.	Oct. 14, 1922
Brakenridge, C. City Engineer, City Hall, Vancouver, B. C., Can.	Nov. 8, 1923
Breitzke, Charles F. Sanitary Engineer, Jersey City Water Works, Boonton, N. J.	June 7, 1910
Brennan, James I. Mng. Engr., Pittsburgh Bureau of Water, 416 City-County Bldg., Pittsburgh, Pa.	Mar. 19, 1924
Bretz, C. E. Supt. City Water Works, City Hall, Oklahoma City, Okla.	Aug. 1, 1923
Bricker, R. P. Prest., Shelby Water Co., Shelby, Ohio.	Nov. 19, 1915
Bridgers, J. H. Prest. Henderson Water Co., 123 N. Garnett St., Henderson, N. C.	June 5, 1923
Brisbin, G. W. Supt., Monroe Water Works, Monroe, Mich.	Aug. 14, 1919
Brockway, Warner C. Engr. Taxpayers League, 213 Torrey Bldg., Duluth, Minn.	May 23, 1923
Brockwell, Sherwood. Deputy, Ins. Comnr., Raleigh, N. C.	Nov. 18, 1921
Bromley, C. H. Munic. Engr., Grimsby, Ont.	June 21, 1920
Bromschwig, A. C. Supt. Filt. and Water Works, 615 119th St., Whiting, Ind.	Apr. 19, 1921
Brooks, James E. Consulting Engineer, 40 Wildwood Terrace, Glen Ridge, N. J.	May 12, 1914
Brooks, John N. 224 West State St., Trenton, N. J.	Feb. 24, 1912
Brossman, Charles. Cons. Engr., 1503 Merchants Bank Bldg., Indianapolis, Ind.	Apr. 7, 1916
Brower, Irving C. City Manager, Pontiac, Mich.	Apr. 18, 1915
Brown, A. R. Prest. Erwin Water Co., Erwin, Tenn.	Feb. 19, 1923
Brown, C. Arthur. Sanitary Engineer, West Erie Pa., R. F. D. 2, Lorain, O.	June 27, 1905
Brown, C. D. Mgr. The Walkerville Water Co., Walkerville, Ontario, Can.	Oct. 16, 1916
Brown, Calvin S. The Belvedere, Toledo, Ohio.	Mar. 15, 1882

Brown, Charles Carroll, C.E. P. O. Box 234, St. Petersburgh, Fla. .... May 12, 1906
Brown, Edward. Supt. Water Works, Eau Claire, Wis. .... Jan. 24, 1921
Brown, Horace A., C.E. Conslt. Engr. and Supt. Water Works, Ottumwa, Iowa .... May 7, 1919
Brown, James. 425 East Olive St., Turlock, Calif. .... Sept. 12, 1922
Brown, Rasselas W. Supt. and Secty., Corry Water Supply Co., Corry, Pa. .... Apr. 3, 1916
Brown, Walter I. City Hall, Bangor, Me. .... Oct. 30, 1914
Brownell, Otto E., C.E. Dvn. of Santn., State Bd. of Hlth., Minneapolis, Minn. .... Mar. 8, 1920
Bruce, John A. Cons. Engr., 120 S. 50th Ave., Omaha, Neb. .... Oct. 21, 1920
Brush, Clinton Frederick. Mgr. Bound Brook Water Co., 419 Summit Ave., Westfield, N. J. .... Jan. 7, 1924
Brush, Wm. W. Deputy Chf. Engr., Dept. Water Supply, Gas and Electy., Municipal Building, New York, N. Y. .... Feb. 18, 1911
Buchanan, Hugh. Compania Consolidada de Aguas, Corrientes del Rosario, Ltd., Rosario de Santa Fe, Argentine. June 25, 1924
Buck, William H. Engr. and Supt. Construction, Riverton and Palmyra Water Co., Riverton, N. J. .... May 7, 1916
Bugbee, Julius W. City Chemist, 290 Massachusetts Ave., Providence, R. I. .... Feb. 20, 1924
Buhrendorf, John C. C.E., 74 Fairview Ave., Yonkers, N. Y. .... Mar. 25, 1924
Bulkeley, Oscar E. Bd. Wtr. and El. Lt. Comn., Lansing, Mich. .... June 23, 1913
Bull, Charles H. Asst. Engr., Dept. W. S. G. and E., 702 Madison Ave., New York, N. Y. .... Mar. 30, 1920
Bull, Irving C. Analytical and Consulting Chemist, 50 West St., New York, N. Y. .... June 8, 1906
Bunker, George Cyrus. P. O. Box 262, Ancon, C. Z. .... Feb. 23, 1911
Bunting, P. G. Mgr. City Point Water Co., Box 11, Petersburg, Va. .... Feb. 7, 1916
Burdick, Charles B. Hydraulic and Sanitary Engr., 1417 Hartford Bldg., Chicago, Ill. .... July 18, 1907
Burgess, Philip. Cons. Engr., 223 East Broad St., Columbus, Ohio .... Apr. 27, 1911
Burnett, Muscoe. Prest. Water Co., Paducah, Ky. .... June 22, 1923
Burnham, Harry A. Engr. & Sp. Insptr. F. M. F. Ins. Co., 68 Brookside Ave., Newtonville, Mass. .... June 16, 1920
Burnie, Arthur N. Supt., Biddeford and Saco Water Co., Biddeford, Me. .... Mar. 22, 1916
Burt, John. Gnl. Mgr. Marin Mcpl. Wtr. Works, 425 5th Ave., San Rafael, Cal. .... May 20, 1920
Burt, L. B. National Lime Association, 77 W. Washington St., Chicago, Ill. .... July 31, 1924
Bushnell, Will B. Spvsg. Engr., C. & U. Water Co., 18 Taylor St., Champaign, Ill. .... Feb. 20, 1922
Buswell, A. M. Chief, State Water Survey Divn., Urbana, Ill. .... Mar. 20, 1916
Buttenheim, Harold S. Editor *The American City*, 443 Fourth Ave., New York, N. Y. .... Mar. 13, 1913
Butts, J. S. City Manager, Wheeling, W. Va. .... Feb. 6, 1924
Butz, George W., Sr. 2301 Boulevard, Wilmington, Del. .... Nov. 20, 1923
Buzby, J. S. Box 310, Burlington, N. J. .... Sept. 30, 1919

Cadman, Robert M. Supt. Engineering Dept., Schedule Rating Office of N. J., 17 Park Ave., Summit, N. J. .... May 28, 1924
Cady, Harrison R. Mech. Engr., Bur. of Water, 795 City Hall, Philadelphia, Pa. .... July 9, 1921

Caird, James M. Chemist and Bacteriologist, Proctor Bldg., Troy, N. Y.	May 16, 1900
Caldwell, James H., C.E. 55 First St., Troy, N. Y.	July 10, 1906
Calhoun, J. W. Meter Foreman, New Chester Water Co., Box 264, Chester, Pa.	May 14, 1921
Calvert, Cecil K. Chemist, Indpls. Sewage Comn., 1902 N. New Jersey Ave., Indianapolis, Ind.	Nov. 22, 1920
Cameron, Archibald Preston. c/o Worthington-Simpson, Ltd., Queens House, Kingsway, London, W. C. 2, Eng.	June 4, 1912
Campbell, C. B. Supt., Bureau of Water, Altoona, Pa.	May 10, 1915
Campbell, Elmer W. State Dept. of Health, Augusta, Maine	Dec. 8, 1923
Campbell, George A. P. O. Box 2002, Reno, Nev.	Apr. 9, 1913
Campbell, Myron G. Mge. St. Albans Water & Ice Co., St. Albans, W. Va.	Feb. 6, 1924
Campion, Harry T. Supt. Water Works, Defiance, O.	Nov. 30, 1920
Canals, J. A. Civil Engineer, P. O. Box 436, San Juan, P. R.	Jan. 7, 1924
Capron, John D. Statistical Engineer, U. S. Cast Iron Pipe & Fdy. Co., Burlington, N. J.	Jan. 30, 1924
Carlin, Phil. Supt. Water Works, Sioux City, Iowa	Apr. 14, 1891
Carr, J. A. Supt., Village Water Dept., Ridgewood, N. J.	May 3, 1916
Carrick, O. W. Wtr. Engr., Wabash Ry., 1636 E. William St., Decatur, Ill.	Sept. 21, 1920
Carroll, Eugene. Vice Prest. and Mgr. Butte Water Co., Butte, Mont.	June 7, 1904
Case, Egbert D. Vice-Pres., Pitometer Co., 50 Church St., New York, N. Y.	Mar. 4, 1921
Casgrain, Charles P. Mgr., Water Works, City Hall, Quebec, Canada	May 20, 1920
Cates, R. H. Pwr. Engr., So. Cal. Edison Co., 1210 Lake St., Los Angeles, Cal.	June 16, 1920
Catlett, George F. San. Engr., State Bd. of Hlth. Bureau of Eng. and Inspcn., Raleigh, N. C.	June 7, 1919
Cavallier, C., C.E. 9–13 Rue Saint-Leon, Nancy, France.	Aug. 31, 1916
Chamberlain, L. H. 725 Jean St., Oakland, Calif.	Jan. 2, 1924
Chambers, George H. Supt. Mntnce., B. of W., 50 Lake View Ave., Buffalo, N. Y.	June 8, 1921
Chambers, John. Chief Engr. and Supt., Louisville Water Co., Louisville, Ky.	June 8, 1921
Chamot, E. M. Prof. Sanitary Chemistry, Cornell University, Ithaca, N. Y.	Feb. 13, 1915
Champe, George, C.E. 610 Nasby Building, Toledo, Ohio.	Mar. 10, 1913
Champion, Roy B. Supt. Public Works, 36 West 12th St., Holland, Mich.	Mar. 11, 1914
Charron, Henry S. Supt. City Water Works, No. 5 City Hall, Burlington, Vt.	Mar. 8, 1924
Chase, Charles P., C.E. 123 Sixth Ave., Clinton, Ia.	Aug. 31, 1916
Chase, Edward Sherman. c/o Metcalf and Eddy, 14 Beacon St., Boston, Mass.	May 3, 1919
Chase, Horace H. 610 West 146th St., New York, N. Y.	May 28, 1924
Chase, Richard D., C.E. 607 Purchase St., New Bedford, Mass.	Nov. 3, 1919
Chester, J. N., H. and M.E. Union Bank Building, Pittsburgh, Pa.	Nov. 7, 1910
Childs, J. A. Engineer, State Board of Health, 1988 Summit Ave., St. Paul, Minn.	Feb. 5, 1917
Chipman, Willis, C.E. Mail Bldg., Toronto, Ont., Can.	Apr. 18, 1888
Chisham, J. M. Supt. Water Co., Atchison, Kans.	June 11, 1902
Chivvis, Leland. Engr. in chge. Dist. Secn., 312 City Hall, St. Louis, Mo.	Oct. 4, 1919
Christensen, C. H. Mgr. Lt. and Water Co., Missoula, Mont.	Oct. 4, 1919

Claflin, Charles R. Supt. Water Co., Rennselaer, N. Y... Sept. 30, 1919
Claiborne, Herbert A. Contracting Engineer, 204 West Franklin St., Richmond, Va.......................... May 7, 1917
Clancy, James M. Comnr. of Finance, Court House, St. Paul, Minn.. June 30, 1922
Clark, A. E. Chemist & Bacteriologist, 233 Storch St., Saginaw, Mich.. June 10, 1919
Clark, Arthur T. Supt. Water Works, Herkimer, N. Y..... May 16, 1919
Clark, Charles M. 105 S. Division St., Peekskill, N. Y..... Apr. 4, 1924
Clark, E. W. American Water Works & Elec. Co., 114 Carman Ave., Operating Dept., Lynbrook, L. I............ Mar. 8, 1924
Clark, Fred. W. G. Water Works Engr., British Municipal Council, Tientsin, N. China........................ June 22, 1923
Clark, H. W. Prest. H. W. Clark Co., Mattoon, Ill....... May 29, 1895
Clark, Harry W. Chf. Chmst., State Dpt. Hlth. Rm. 541, State House, Boston, Mass........................... May 26, 1920
Clark, William G. Cons. Engr., 1047 Spitzer Bldg., Toledo, Ohio.. July 8, 1908
Clark, William H. Supt. Water Works, Avon, N. Y....... May 31, 1916
Clark, William L. Chemist, Wyandotte Filt. Plnt., 5 Superior Blvd., Wyandotte, Mich...................... Sept. 21, 1920
Clark, William Mansfield. Prof. Chemistry, Hygienic Lab., U. S. P. H. S., 25th and E. Sts., Washington, D. C. June 9, 1921
Clarke, Leonard. Distr. Mgr., 814 Main St., Vancouver, Wash.. Mar. 5, 1921
Clay, Joe. Supt. Water Works, Carlisle, Ky............... Jan. 7, 1924
Clayton, R. M. American Savings Bank, Atlanta, Ga...... Apr. 5, 1891
Cleflin, Edwin J. 50 Jefferson Ave., Jersey City, N. J.... May 28, 1924
Clemens, O. E. Mgr., Wtr. Sales, S. V. Wtr. Co., 375 Sutter St., San Francisco, Cal.............................. Feb. 10, 1921
Clemmitt, Robert L. 3625 Springdale Ave., Baltimore, Md.. Aug. 27, 1910
Cleveland, E. A. Cons. Engr., Dept. of Lands, Parliament Bldg., Victoria, B. C., Canada....................... Mar. 12, 1924
Cleveland, H. Burdette. Cons. San. Engr., 38 Park Row, New York City.................................... Aug. 1, 1923
Cleverdon, Walter S. L. Supvsr. of Property Ass. Prof. of Sanitary Engineering N. Y. Univ., Bronx, New York, Apr. 3, 1916
Clifton, Charles Elmer. Chemist, Proctor Bldg., Troy, N. Y.. Mar. 12, 1910
Clinton, Jacob S. Supt. Bureau of Water, Schenectady, N. Y.. Feb. 23, 1924
Cobleigh, W. M. Professor of Chemistry, Montana State College, Bozeman, Mont............................. Dec. 29, 1913
Coburn, James W. Treasr. Rensselaer Water Co., P. O. Box 868, Portland, Me.................................. Feb. 19, 1923
Cochran, Horace J. Pres., Maysville Water Co., Maysville, Ky.. May 28, 1924
Cochran, J. D. Supt. Water Works, Statesville, N. C........ Dec. 8, 1923
Code, R. W., C.E. 116 Chatham St. W., Windsor, Ont....... Aug. 4, 1922
Coe, Ralph B. Asst. Engr., Board of Water Supply N. Y. C., 105 S. Division St., Peekskill, N. Y.................... Mar. 25, 1924
Coffin, T. DeL. Asst. Engr., Bureau Water Supply City of N. Y., Katonah, N. Y................................ Apr. 14, 1922
Cole, Edward S. Prest., The Pitometer Co., 50 Church St., New York, N. Y.. June 12, 1902
Collins, A. Water Comnr., 29 Jepson St., Niagara Falls, Ont. June 8, 1921
Collins, Edward H. Chf. Dftsmn. Bd. Wtr. Cmnrs., 914 E. Jefferson Ave., Detroit, Mich......................... May 29, 1920
Collins, M. F. Supt. Water Works, Lawrence, Mass......... June 21, 1920

Conard, W. R. Savings Institution Bldg., Burlington, N. J.	June 7, 1904
Connor, F. J. Supt. Water Works, Sioux Falls, S. Dak.	May 16, 1900
Connor, Thomas J. Supt. Water and Light Dept., Gilbert, Minn.	June 2, 1920
Cook, John H. Hyd. Engr., East Jersey Water Co., 158 Ellison St., Paterson, N. J.	July 10, 1906
Corbin, Clement K. Dctr. Middlesex Water Co., 243 Washington St., Jersey City, N. J.	May 12, 1908
Corcoran, Harry J. Chf. Engr. Iowa Ins. Serv. Bur., 716 Securities Bldg., Des Moines, Iowa	Jan. 2, 1924
Corey, Ray Howard. Gnl. Mgr., Coos Bay Water Co., Marshfield, Ore.	June 19, 1920
Corin, Magnus F. Chemist, 511 Hansberry St., Germantown, Pa.	Apr. 20, 1910
Corp, Charles I., Prof. Hyd. & San. Eng., Univ. of Wis., Madison, Wis.	Mar. 21, 1923
Coscculluela, Juan Antonio. Cons. Engr., O'Reilly y Mercaderes, Havana, Cuba	Oct. 16, 1913
Costa, Joseph D. 1509 Albany Terrace, Albany, Calif.	Sept. 17, 1923
Coughlan Robert E. Sprvsr. Wts. Sup. C. & N. W. R. R., 109 S. Karlov Ave., Chicago, Ill.	Feb. 28, 1923
Coulter, Waldo S. Cons. Engr., 114 Liberty St., New York, N. Y.	Nov. 17, 1916
Cousineau, Aimé. City San. Engr., Health Dept., City Hall, Montreal, Canada	June 10, 1920
Cowan, P. H. Supt. Pub. Util., Galt, Ont.	June 9, 1919
Cowles, M. Warren. 82 Mill Plain Rd., Fairfield, Conn.	Apr. 7, 1919
Cox, Charles R. Asst. Engineer, State Department of Health, Albany, N. Y.	July 30, 1921
Cox, George W. Supt. of City Utilities, Harlan, Iowa	Oct. 31, 1923
Cox, Homer F. Chief Engr. Scranton Gas and W. Co., 430 Colfax Ave., Scranton, Pa.	May 12, 1914
Cox, Lawrence W. R. F. D. No. 2, Iron Mountain, Mich.	Dec. 26, 1919
Craig, Edward M., Jr. San. Engineer, Charlotteburg, N. J.	Oct. 11, 1923
Craig, J. O. Supt. Water Works, Salisbury, N. C.	May 24, 1922
Craig, Robert Hall. Cons. Engr., 200 Telegraph Bldg., Harrisburg, Pa.	May 26, 1919
Cramer, Hugh R. Asst. Chf. Engr. Lexington Wtr. Co., Lexington, Ky.	May 23, 1923
Cramer, W. S. Chf. Engr., Water Co., P. O. Box 42, Lexington, Ky.	May 12, 1908
Cranch, Eugene T. City San. Engr., 329 St. Andrews St., Petersburg, Va.	Mar. 19, 1922
Crane, Arthur M. 405 Chestnut St., Roselle Park, N. J.	May 26, 1918
Crawford, Homer C. Prest. Centerville Water Co., Cooperstown, Pa.	June 6, 1919
Crichton, Andrew B. Secty. and Trs., Portage Water Co., Johnstown, Pa.	May 29, 1915
Cripps, George R. Supt., Water Works Repair Dept., 18 Eagle St., Rochester, N. Y.	June 8, 1909
Crockett, Harvey S. City Superintendent, 118 Schiller St., Elmhurst, Ill.	Jan. 26, 1924
Crofoot, E. H. Supt. City Water Works, Mason City, Iowa	Oct. 5, 1923
Croft, H. P. Ch. Eng. State Dept. of Health, 208 Maple Ave., Trenton, N. J.	Jan. 7, 1924
Croll, Emiel A. Supt. Water Works, Iron Mountain, Mich.	Sept. 7, 1893
Crounse, Avery F. Mgr. Sanitor Construction Co., 4323 Dupont Ave., So., Minneapolis, Minn.	May 8, 1920
Crow, J. W. Supt. of Water & Light, Ponca City, Okla.	Feb. 23, 1924

Crowley, Cornelius M. Water Registrar, St. Paul, Minn...	Oct. 18, 1918
Crozier, Ray. Engr. and Supt., Peoria Water Works, Peoria, Ill.	Feb. 5, 1915
Crum, Emory Clay. City Engineer, P. O. Box No. 354, Frederick, Md.	Feb. 13, 1924
Cuddeback, Allan W. Engr. and V. P. Passaic Water Co., 158 Ellison St., Paterson, N. J.	June 7, 1904
Culyer, Thurston C., C.E. 135 East 95th St., New York, N. Y.	June 26, 1910
Cunningham, F. G., C. E. Fuller & McClintock, 879 North Parkway, Memphis, Tenn.	Apr. 30, 1923
Cunningham, Joseph T. Supt., Flatbush Wtr. Wks. Co., 48 St. Pauls Place, Brooklyn, N. Y.	Nov. 25, 1921
Currie, C. H. Cons. Engr., Webster City, Ia.	Apr. 20, 1920
Curtis, J. Eugene. Filtn. Plant, Washington, D. C.	May 3, 1923
Cutts, Francis T. Asst. Water Com'r., 34 East Grand Ave., St. Louis, Mo.	June 15, 1914
Daily, Cornelius M. Engr. in Chge. of Supply and Purif. Sect., St. Louis Water Dept., St. Louis, Mo.	Apr. 4, 1918
Dallyn, F. A., C.E. Provincial Sanitary Engineer, Spadina House, Spadina Cres., Toronto, Ont.	Feb. 2, 1916
Dames, Erwin. Village Hall, Winnetka, Illinois.	June 9, 1922
Daniel, Frank R. Chief Engr., Wisconsin Inspec. Bureau, 490 Broadway, Milwaukee, Wis.	Aug. 18, 1924
Daniels, Francis E. Eng. Div. State Dept. of Health, 2115 N. Second St., Harrisburg, Pa.	Sept. 2, 1916
Dappert, James W., C.E. Lock Box 141, Taylorville, Ill.	Oct. 23, 1914
Davidson, George M. Ind. Engr., C. & N. W. Ry. Co., 226 W. Jackson Blvd., Chicago, Ill.	Mar. 11, 1915
Davis, Arthur P. 505–17th St., Oakland, Calif.	Feb. 9, 1924
Davis, Carl E. Resd. Engr. Bd. Wtr. Comnrs., 105-7 N. 2nd St., Memphis, Tenn.	June 1, 1923
Davis, Carleton E. Mgr. Indianapolis Wtr. Co., 113 Monument Circle, Indianapolis, Ind.	Apr. 28, 1912
Davis, E. E. Div. Supt., Bureau of Water, Richmond, Va.	May 12, 1908
Davis, Frank J. Supt., Ansonia Water Co., 354 Main Street, Ansonia, Conn.	May 15, 1916
Davis, H. F. Representing Wallace & Tiernan, c/o Charlotte Water Wks., Charlotte, N. C.	Dec. 8, 1923
Davis, P. D. Asst. Engr., Wm. M. Piatt, Durham, N. C.	Jan. 12, 1922
Davis, W. L. Supt., Water Dept., P. O. Box 266, Portsmouth, Va.	July 8, 1922
Daw, Lawrence. Chf. Engr., Underwriters Assn. of N. Y., 700 Gurney Building, Syracuse, N. Y.	May 9, 1916
Day, E. L. Mgr. Princeton Water Works Co., 816 Mercer St., Princeton, W. Va.	May 27, 1922
Day, Leonard A. Chf. Mech. Engr., St. Louis Water Dept., 34 E. Grand Ave., St. Louis, Mo.	Apr. 24, 1917
DeBerard, W. W. Western Editor, *Engineering News-Record*, 1570 Old Colony Bldg., Chicago, Ill.	June 3, 1912
DeCamp, Guy. Supt., Water & Light Dept., La Grange, N. C.	Apr. 23, 1924
Decker, Arthur J. Consulting Civil Engr., 2014 Geddes Ave., Ann Arbor, Mich.	May 23, 1923
Decker, A. Clinton. Sanitary Engr., Tenn. Coal, Iron & Railroad Co., Birmingham, Ala.	June 2, 1914
Decker, David A. c/o Lock Joint Pipe Co., Box 21., Ampere, N. J.	June 21, 1920
DeLeuw, Charles E. Kelker, DeLeuw & Co., Engrs., 111 W. Washington St., Chicago, Ill.	Nov. 30, 1923

DENMAN, CHARLES SING. Genl. Mgr. Des Moines Water Co., Des Moines, Iowa	Dec. 10, 1915
DENNETT, ROBERT C. Hyd. Engr., c/o Natl. Board Fire Underwriters, 76 William St., New York, N. Y.	May 15, 1914
DETTRA, L. R. City Manager, Winchester, Virginia	June 11, 1924
DETWILER, L. F. Supt., Goldfield Consol. Water Co., Goldfield, Nevada	June 28, 1924
DEVENDORF, EARL. Asst. San. Engr. St. Dept. of Hlth., 1239 Albany St., Schenectady, N. Y.	May 22, 1919
DEVILBISS, H. ROLAND. Dept. Engr., Washington Suburban Sanitary Dist., Hyattsville, Md.	Apr. 10, 1922
DEWEY, ALVIN H. V. P. & Gen. Mgr. Rochester & Lake Ontario Wtr. Co., Bx. 185, Rochester, N. Y.	May 23, 1923
DIEHL, GEORGE C. Cons. Engr., 577 Elicott Square, Buffalo, N. Y.	May 15, 1923
DIGGS, FRANKLIN, JR. San. Engr., Linthicum Heights, Md.	Sept. 11, 1923
DIGGS, JOHN C. San. Engr., Department of Conservation, 126 State Capitol, Indianapolis, Ind.	Sept. 9, 1919
DIGNAN, B. T. Chem. and Bact., City Water Works, Niagara Falls, N. Y.	Apr. 10, 1919
DILL, H. A. Supt., Water Works, Richmond, Ind.	May 16, 1900
DILLER, J. W. Superintendent, Water Works, Wilber, Nebr.	July 31, 1924
DISSEL, J. A. Supt. Municipal Elec. Light & Waterworks, Crescent City, Fla.	Apr. 10, 1924
DITTOE, W. H. Chief Engr., State Department of Health, Columbus, Ohio	May 28, 1914
DIVEN, J. M., Jr., C. E. 235 W. 71st St., New York, N. Y.	June 17, 1913
DIXON, FREDERIC JOHN. Chf. Engr. Staffordshire Wtr. Wks., 264 Paradise St., Birmingham, England	Aug. 8, 1919
DIXON, G. GALE. Consulting Engineer, 1119 Tremont Bldg., Boston, Mass.	June 21, 1920
DIXON, J. H. Superintendent Water Dept., Lillington, N. C.	Dec. 8, 1923
DOANE, NORMAN D. Apt. 708, 2035 No. Meridan St., Indianeapolis, Ind.	May 31, 1921
DOBBIN, R. L. Supt. Water Works, 223 Aylmer St., Peterborough, Ont.	Feb. 28, 1923
DODD, RENNIE I. Chemical Engr., P. O. Box 1353, Charleston, W. Va.	Apr. 10, 1922
DONAHUE, COL. JAMES P. Colfax, Ia.	Apr. 16, 1884
DONALDSON, WELLINGTON. c/o Messrs. Fuller & McClintock, 170 Broadway, New York, N. Y.	Apr. 29, 1910
DONNELLY, R. V. Pres., The Paradon Engr. Co., 24 So. Washington Place, Long Island City, N. Y.	Apr. 7, 1917
DONOHUE, JERRY. Prest., Donohue Engineering Co., Sheboygan, Wis.	June 20, 1922
DOOLEY, P. J. Supt., Water Works, 319 Third Ave., Joliet, Ill.	May 15, 1922
DORRANCE, FRANK YOUNG. Divn. Engr., Montreal Water Bd., 341 Brock Ave., North, Montreal West, P. Q., Can.,	July 14, 1920
DORSEY, STANTON, L. V. P., Knox Engineering Corp., 120 Broadway, New York, N. Y.	May 28, 1924
DOTEN, CAPT. LEONARD S. U. S. Army, Schuylkill Arsenal, 2520 Gray's Ferry Road, Philadelphia Pa.	Aug. 19, 1914
DOUGHERTY, BEN R. Supt., Richmond Water & Light Co., Richmond, Ky.	Apr. 16, 1924
DOUGHERTY, M. J. Pres., M. J. Dougherty Corp., 25th St. & Washington Ave., Philadelphia, Pa.	May 28, 1924
DOUGHERTY, ROBERT E. Supt. West Palm Beach Water Co., West Palm Beach, Fla.	Feb. 7, 1922
DOUGLAS, RAY E. Supt. Water Works, Canandaigua, N. Y.	Mar. 31, 1919

Douglass, Robert M., C. E. 912 Columbia Bank Bldg., Pittsburgh, Penn.	May 12, 1923
Dow, Alex. 2000 Second Ave., Detroit, Mich.	Aug. 4, 1919
Dowd, John E. 162 85th St., Brooklyn, N. Y.	Mar. 4, 1922
Dowling, F. F. Chief Engineer, British Columbia Fire Undwtrs., 1021 Rogers Bldg., Assoc., Vancouver, B. C., Canada	May 31, 1924
Downes, John R. Green Brook Park, Bound Brook, N. J.	July 10, 1906
Drake, Chester F. Div. Supt., Pittsburgh Filtration Plant, Aspinwall, Pa.	Apr. 27, 1910
Drake, Edward, C.E. New Bedford, Mass.	Jan. 29, 1921
Drake, William O. City Engr., Supt. Public Works, City Hall, Corning, N. Y.	Apr. 30, 1917
Drane, Brent S. N. C. Geo. & Economic Survey, Chapel Hill, N. C.	June 28, 1924
Druar, John F. Cons. Engr., 500–4 Globe Bldg., St. Paul, Minn.	Nov. 18, 1919
Dryden, Francis H. City Engineer, Salisbury, Md.	May 13, 1924
Duffy, James M. Village Engineer, Mamaroneck, N. Y.	June 6, 1922
Duggan, Thomas R., Ph.D., F.I.C. Chemists Club, 52 East 41st St., New York, N. Y.	Dec. 9, 1913
Dugger, Eugene F. Acting Supt. Newport News L. & W. Co. 2410 Wesh Ave., Newport News, Va.	May 17, 1924
DuMoulin, W. L. Asst. Gnl. Supt., New Cornelia Copper Co., Ajo, Arizona	June 18, 1910
Dunham, H. F., C.E. 32 West 40th St., New York, N. Y.	Apr. 16, 1884
Dunlap, Fred C. 6621 No. 12th St., Philadelphia, Pa.	May 12, 1908
Dunlap, John H. 33 West 39th St., New York, N. Y.	Apr. 7, 1917
Dunn, Wm. Carey. Supt. Mt. Hope Filter Plant, Box 541, Cristobal, C. Z.	Nov. 12, 1919
Dunwoody, J. S. Supt., Water Department, Erie, Pa.	June 5, 1913
Durbin, W. H. C. E. Asst. Mgr. T. H. Water Works Co., 634 Cherry St., Terre Haute, Ind.	May 23, 1923
Durland, Smith N. Cashier, Queens Co. Water Co., 15 John St., Far Rockaway, N. Y.	Jan. 29, 1914
Durst, J. Arthur, M.E. 112 N. Broad St., Philadelphia, Pa.	May 15, 1914
Dwyer, Cornelius. 18 Chuctanunda St., Amsterdam, N. Y.	Apr. 11, 1914
Dwyer, John D. Chairman, Water & Sewer Board, 228 Spring St., Medford, Mass.	May 24, 1922

Earl, George Goodell. Genl. Supt., 402 Sewerage and Water Bd. Bldg., New Orleans, La.	July 18, 1907
Earl, Ralph. Hyd. Engr., c/o Sewerage and Water Board, Water Purification Dept., New Orleans, La.	June 6, 1916
Early, F. A. Supt., Water Works, Brampton, Ont.	May 24, 1922
Easby, William A., Jr. Civil & Sanitary Engr., 1201 Chestnut St., Philadelphia, Pa.	Mar. 12, 1924
Eastwood, John Thompson. Prin. Asst. Engr., Sewer and Water Bd., City Hall Annex, New Orleans, La.	May 24, 1909
Edwards, William R. Asst. Supt. Passaic Water Co., 156 Ellison St., Paterson, N. J.	Apr. 2, 1914
Eglof, Warren K. Chemist & Bacteriologist, 11 Grand St., Newburgh, N. Y.	June 11, 1924
Ehle, Chester G. Chf. Dftsmn. & Distbn. Engr. Wtr. Bureau, 211 City Hall, Portland, Ore.	Mar. 21, 1923
Ehrhart, C. L. Supt. Water Works, Box 187, Boone, Ia.	Apr. 30, 1919
Eldredge, Guy. Vacaville, Cal.	Dec. 29, 1916
Eldridge, H. D. Treas., Princeton Water Company, Princeton, N. J.	Apr. 14, 1916

ELLIOTT, G. A. Chf. Engr., Spring Valley Water Co., 425 Mason St., San Francisco, Calif. . . . . May 15, 1918
ELLIS, E. W., C.E. Box 482, Honolulu, T. H. . . . . Sept. 26, 1921
ELLIS, LUKE. Serv. Engr., Pub. Serv. Comm. of Md., 1722 Munsey Bldg., Baltimore, Md. . . . . Sept. 23, 1924
ELLIS, N. RANDALL. Valtn. Engr. City Atty. Office, 453 City Hall, San Francisco, Cal. . . . . June 9, 1920
ELLMS, JOSEPH W. 1263 Cook Ave., Lakewood, Ohio. . . . . Oct. 21, 1919
ELLSWORTH, HARRY. Supt. Water and Light Dept., Meadville, Pa. . . . . July 18, 1907
ELROD, HENRY E. Cons. Engr., Elrod Bldg., 3206 Elm St., Dallas, Tex. . . . . Feb. 2, 1916
ELSBERG, N. W. City Engr., 203 City Hall, Minneapolis, Minn. . . . . May 23, 1923
ELY, HOWARD M. Superintendent Water Co., Danville, Ill. . . . . June 8, 1909
ELY, JOHN STANTON. Asst. Engr., Bur. of Water, 796 City Hall, Philadelphia, Pa. . . . . Mar. 20, 1922
EMERSON, C. A., JR. c/o Fuller & McClintock, Rm. 601, 1001 Chestnut St., Philadelphia, Pa. . . . . May 12, 1908
EMERSON, FRANK. City Engr. and Supt. Water Dept., Peabody, Mass. . . . . Nov. 12, 1919
ENANDER, E. H. Engr., Distribution Public Service Co. Northern Ill., 75 W. Adams St., Chicago, Ill. . . . . June 27, 1922
ENGEL, P. N. 333 W. 25th Place, Chicago, Ill. . . . . June 12, 1919
ENGER, M. L. Prof. Mechanics and Hydraulics, Univ. of Ill., Urbana, Ill. . . . . Mar. 11, 1915
ENGH, HARRY M. Mgr. Pub. Util. Dept., American Appraisal Co., Milwaukee, Wis. . . . . Mar. 25, 1916
ENGLAND, R. G., C.E. Fargo Engineering Co., 147 So. Mechanic St., Jackson, Mich. . . . . Sept. 2, 1914
ENGLE, JAMES W. Big Bethel Water Development, R. F. D. No. 2, Box 110, Hampton, Va. . . . . Sept. 4, 1923
ENO, F. H., C.E. Ohio State University, Columbus, Ohio. . . . . Dec. 2, 1913
ENSLOW, LINN HARRISON. San. Engr., State Dept. of Hlth., 110 Capitol St., Richmond, Va. . . . . Aug. 16, 1918
ERICKSON, D. L. City Engineer, Lincoln, Nebr. . . . . June 30, 1924
ERICKSON, WENDELL J. Asst. Sanitarian, State Dept. of Health, 1552 Nott St., Schenectady, N. Y. . . . . Jan. 19, 1924
ERVAST, ANDREW. Mgr., Coronado Water Co., 440 Union Bldg., San Diego, Calif. . . . . Oct. 11, 1923
ESTY, ROGER W. Supt., 17 Hobart St., Danvers, Mass. . . . . Mar. 1, 1924
ETNYRE, S. L. Supt. Water Works, Council Bluffs, Iowa. . . . . May 10, 1915
ETZEL, GEORGE C. Analyst, 1101 12th Ave., Rock Island, Ill. . . . . June 5, 1916
EVANS, CHARLES. Supt. of Constr., 540 Haller St., Lima, O. May 26, 1923
EVERETT, CHESTER M. Of Hazen and Whipple, 25 W. 43rd St., New York, N. Y. . . . . May 10, 1915
EVERETT, JASPER W. Supt., Penobscot Co. Wtr. Co., Orono, Me. . . . . May 5, 1922
EVERETTE, WILLIS EUGENES. P. O. Box 188, San Rafael, Calif. . . . . Dec. 29, 1913
EVINGER, M. I. Cons. Civ. and San. Engr., Sta. A., Lincoln, Neb. . . . . Jan. 31, 1910
EWING, JAMES. Hunter Dist. Water Sup. and Sew. Bd., Newcastle, N. S. W., Australia. . . . . Nov. 5, 1913
EWRY, RAY C. Municipal Bldg., Rm. 2200, New York, N. Y. . . . . Apr. 4, 1924
EYMER, HERMAN H. City Engineer, Saginaw, Mich. . . . . June 4, 1912

FAGER, E. P. Bct. and Chst. Dearborn Chem. Co., 1029 W. 35th St., Chicago, Ill. . . . . Aug. 5, 1920

Fagg, J. H. 123 Sutter St., Stockton, Calif.................. Nov. 8, 1923
Fairchild, W. H. Mgr. Pub. Util., Galt, Ont................ June 9, 1915
Fales, Almon L. Of Metcalf & Eddy, Cons. Engrs., 14 Beacon St., Boston, Mass............................ Feb. 26, 1921
Faller, C. Supt., Carlisle Gas and Water Co., Carlisle, Penn. May 8, 1909
Farmer, John T. Mechanical & Hydraulic Engr., 314 Coristine Bldg., Montreal, Canada........................ Mar. 8, 1924
Farmer, Ollef O. Supt. of Water Dept., 511 Peimento St., Inglewood, Calif.................................. Nov. 8, 1923
Farquharson, Alex. L. Mgr. Brockville Public Utilities Victoria Hall, Brockville, Ont., Can...................... Mar. 8, 1924
Farrar, H. L. Dist. Mgr., Southern Illinois Gas Co., Murphysboro, Ill...................................... Oct. 21, 1920
Farrell, James W. D. Asst, Supt. Water Works, 3025 Rae St., Regina, Sask.................................. Feb. 23, 1920
Farrell, Thomas S. 1303 Wset Blvd., Cleveland, O.......... June 7, 1921
Fauco, Hernando Gomez. Apartado No. 151, Bogota, Colombia.. Mar. 1, 1924
Feeney, A. J. Asst. Engr. and Supt. Water Dept., Wilmington, Del.. Apr. 30, 1919
Feeter, Silas S. City Engr. & Supt. Water Works, Little Falls, N. Y.. Oct. 22, 1921
Feist, Martin. Supt. Mch. Eqpt. St. P. Wtr. Wks., Dayton's Bluff Stn., B. 4, St. Paul, Minn........................ May 13, 1919
Felix, George H. 138 N. Ninth St., Reading, Pa........... Sept. 7, 1893
Fellows, C. L. Water Works Engineer, 39 Lowther Ave., Toronto, Can...................................... June 7, 1904
Fenkell, George H. Supt. and Gnl. Mgr. Bd. Wtr. Comnrs., Cor. Jefferson and Randolph, Detroit, Mich.......... June 21, 1920
Ferguson, Emery E. Supt., West Virginia Water & Electric Co., Charleston, W. Va.............................. Apr. 10, 1922
Ferguson, Harry Foster. Chf. Eng., State Dept. of Hlth., Springfield, Ill.................................... Nov. 9, 1914
Ferguson, John B., C.E. Hagerstown, Md................. Sept. 30, 1919
Ferguson, S. F. Cons. Engr., 10 E. 44th St., New York, N. Y.. Dec. 5, 1914
Ferris, T. E. Chrmn. Wtr. Comnrs., Niagara Falls, Ont..... Feb. 10, 1921
Fetzer, John Bernard. Supt. City Water Dept., 347 E. Stephen St., Martinsburg, W. Va...................... Feb. 6, 1924
Field, Frederick E. Engr. Water Bd., 135 Ballantyne Ave., Montreal, West, P. Q.............................. June 21, 1920
Field, William T. Cons. Engr., Flower Bldg., Watertown, N. Y.. Apr. 27, 1910
Fields, F. V. Supt., Water & Light Dept., Mooresville, N. C. Apr. 23, 1924
Fiesler, Fred A. 145 E. High St., Edwardsville, Ill........ June 20, 1922
Fifield, Gilbert H. Asst. Engr., Board of Water Supply N. Y. C., Prattsville, N. Y.............................. Mar. 19, 1924
Filbert, W. D. 412 N. Fifth St., Reading, Pa.............. Apr. 27, 1910
Filby, Ellsworth L. State San. Engr., State Bd. of Hlth., Columbia, S. C..................................... Feb. 7, 1922
Fink, G. J. Chem. Director, National Lime Association, 918 G. Street, Northwest, Washington, D. C............... Apr. 8, 1924
Finkle, F. C. Cons. Hyd. Engr., 449 I. W. Hellman Building, Los Angeles, Cal................................ June 24, 1912
Finlay, W. S., Jr. Vice Pres. Amer. Wtr. Wks. and El. Co., 50 Broad St., New York, N. Y........................ Nov. 30, 1920
Finlayson, John N. Univ. of Manitoba, Eng. Bldg., Sherbrooke & Portage, Winnipeg, Canada................. Feb. 28, 1923
Finneran, Geo. H. Supt. Water Service, 710 Albany Ave., Boston, Mass...................................... Feb. 18, 1921

Fisher, E. A. Consulting Engineer, Rochester, N. Y........ June 4, 1912
Fisher, L. A. P. O. Box 198, Concord, N. C................ Jan. 27, 1914
Fitzgerald, Howard. Chf. Engr. Buffalo Wtr. Wks., 128 Congress St., Buffalo, N. Y........................ Apr. 20, 1923
Flaa, Ingwald E. Asst. Engr., Spring Valley Water Co., 425 Mason St., San Francisco, Cal.................... May 14, 1915
Flack, Horace E. Executive, Dept. Legislative Reference City Hall, Baltimore, Md........................... June 16, 1919
Flad, Edward. 1312 Chemical Bldg., St. Louis, Mo........ July 23, 1919
Flannery, William. M. E. Dept., W. S. G. and E., N. Y., 97 Park Ave., Brooklyn, N. Y........................ May 9, 1921
Fleming, Virgil R. 204 Lab. App. Mech., Urbana, Ill....... Apr. 14, 1915
Flinn, Alfred Douglas. Secty. United Eng. Soc., Room 1617, Eng. Soc. Bldg., New York, N. Y................ Mar. 1, 1916
Flint, George M. 14 Beacon St., Room 613, Boston, Mass. Oct. 14, 1922
Flower, G. E. San. Engr., Room 211, City Hall, Cleveland, Ohio.. June 8, 1921
Foerster, John Addison. Mangr., Hydro-Electric & Water Works Coms., Kincardine, Ontario.................. Apr. 24, 1922
Foley, Harry F. Supt., Water Bureau, 196 Riverdale Ave., Yonkers, N. Y.. Feb. 7, 1922
Folwell, A. Prescott. Municipal Engineering Consultant, Park Row Bldg., New York, N. Y.................. July 10, 1906
Foote, Francis C. 507 Westinghouse Bldg., Pittsburgh, Pa. May 28, 1924
Foote, Herbert B. Director, Div. Water & Sewage, State Board of Health, Helena, Mont....................... Aug. 1, 1923
Ford, J. W. Engr. San Jose Water Works, 374 W. Santa Clara St., San Jose, Calif................................. Jan. 26, 1924
Foreman, Charles S. 1st Asst. Engr. & Mgr. Wtr. Dept., 2nd Floor, City Hall, Kansas City, Mo.............. June 21, 1920
Forristel, F. E. Supt. Water Works, Eveleth, Minn........ June 9, 1919
Forsberg, Ole. Chst., Oliver Iron Mining Co., Hibbing, Minn.. Mar. 14, 1921
Foss, W. E. Dctr. and Chf. Engr., Water Dvn., Mtrptn. Dist. Comn., 1 Ashburton Place, Boston, Mass......... July 10, 1906
Foster, Charles. Cons. Engr., 512 Selwood Bldg., Duluth, Minn.. June 9, 1919
Foulks, John A. Chf. Engr., Divn. of Wtr., Newark, N. J... Dec. 23, 1921
Fowler, Arthur G. Supt. Water Works, R. F. D. 3, Cumberland, Md... Apr. 27, 1910
Fowler, Edward A. Asst. Engr. 207 Swrge. and Wtr. Bd. Bldg., New Orleans, La.............................. Apr. 27, 1910
Fox, Charles L. Asst. Supt., Pennsylvania Water Co., 712 South Avenue, Wilkinsburg, Pa...................... June 4, 1912
Fox, Robert L. City Engr., 37 E. Broad St., Bethlehem, Pa.. May 24, 1922
Frank, Fred W. Secty. and Mgr. Water Works, Brantford, Ont., Can.. July 18, 1907
Frazier, J. W. Cons. Engr., B. F. Keith Bldg., Cleveland, O. June 8, 1921
Frederick, W. Dayton. Bridgeton Water Works, Bridgeton, N. J.. May 12, 1914
Freeburn, H. M. Dist. Engr., State Dept. of Hlth., 1903 Green St., Harrisburg, Pa.......................... May 5, 1922
Freeman, Allen W. Res. Lecturer, Hygiene & Pub. Hlth., Johns Hopkins, 310 W. Monument St., Baltimore, Md... July 12, 1922
Freer, W. D. American Water Works & Elec. Co., 50 Broad St., New York, N. Y.............................. Mar. 8, 1924
Freiling, Henry J. 625 Grand Ave., Hannibal, Mo......... May 12, 1914
French, D. W. Supt. Hackensack Water Co., P. O. Box 98, Weehawken, N. J...................................... May 29, 1895

French, Dudley K. Chemist, Dearborn Chemical Co., 2005 McCormick Building, Chicago, Ill.	May 25, 1919
French, E. V., M.E. 185 Franklin St., Boston, Mass.	July 10, 1906
Fretter, A. H. Supt., Water Works, 603 S. Broadway, Medina, O.	Feb. 7, 1922
Frick, Walter S., C.E. East Falls Church, Virginia	Nov. 21, 1922
Fritz, William G. Contractor, West Orange, N. J.	May 28, 1924
Fuertes, James H. Cons. Engr., 140 Nassau St., New York, N. Y.	July 10, 1906
Fuller, George W. 170 Broadway, New York, N. Y.	June 15, 1898
Fuller, W. A. Cons. Engr., 1917 Railway Exc. Building, St. Louis, Mo.	Oct. 14, 1914
Fuller, Weston E., C.E. Swarthmore College, Swarthmore, Pa.	May 27, 1922
Fullerton, Howard R. State San. Engr., Tenn. St. Bd. of Health, 405 7th Ave. North, Nashville, Tenn.	Jan. 9, 1923
Furman, Robert W. Chf. Chemist, Water Purification Works, 1443 Kenyon Drive, Toledo, Ohio	May 25, 1922
Gaby, Frederick A. Chf. Engr., Hydro-Electric Power Com. of Ont., 190 University Ave., Toronto, Ont., Canada	Feb. 8, 1916
Gaillard, G. Y. Pres., New Haven Water Co., 100 Crown St., New Haven, Conn.	May 27, 1924
Gallagher, H. A. Mgr. Water Co., Independence, Mo.	June 8, 1909
Gammon, J. E. Gen. Mgr., The Sheffield Co., Sheffield, Ala.	Feb. 23, 1924
Gannett, Farley. Prest., Gannett, Seelye and Fleming, Engrs., 204 Locust St., Harrisburg, Pa.	Nov. 29, 1919
Garman, H. O. Consulting Engineer., 2062 N. Meridian St., Indianapolis, Ind.	May 30, 1916
Gascoigne, George B. Consulting Sanitary Engr., 648 Leader-News Bldg., Cleveland, O.	June 16, 1920
Gates, H. V. Prest., Hillsboro Power and Invest. Co., Hillsboro, Oregon	June 7, 1904
Gaunt, Percy. Chief Sanitation Chemist, c/o Shanghai Municipal Council, Shanghai, China	Sept. 12, 1922
Gausmann, Roy W. Division Engineer, New York City Board of Wtr. Sup., Grand Gorge, N. Y.	Mar. 12, 1924
Gavett, Weston. Analyst, 312 W. 5th St., Plainfield, N. J.	Nov. 10, 1914
Gear, Patrick. Supt. Water Dept., Holyoke, Mass.	June 24, 1913
Geehan, Edward A. American Water Works & Elec. Co., 50 Broad St., New York, N. Y.	Feb. 6, 1924
Gelston, W. R. Supt. Water Works Commission, Quincy, Ill.	May 7, 1907
Gensheimer, George C. Secty. Comrs. of Water Works, Erie, Pa.	June 22, 1919
Georgia, Frederick Raymond. Dept. of Chemistry, Cornell Univ., Ithaca, N. Y.	May 16, 1919
Gerardy, Maurice N. Pitometer Opt., 176 E. Jefferson Ave., Detroit, Mich.	Mar. 16, 1922
Gerber, Winfred D. C.E., 892 Vernon Ave., Glencoe, Ill.	Apr. 19, 1915
Gerhard, Norman P., C.E. Scarsdale, New York, N. Y.	Oct. 21, 1919
Gettrust, J. S. Supt. Akron Filt. Plnt., Kent, O.	June 8, 1921
Geupel, Louis A. Room 152, Basement State House, Indianapolis, Indiana	Nov. 28, 1922
Giacomazzi, P. A. 335 Pleasant St., Santa Paula, Calif.	Nov. 8, 1923
Gibbons, Mortimer M. 61 Warren Ave., Mattapan, Mass.	Nov. 9, 1922
Gibson, James E. Manager & Engr., Water Dept., 14 George St., Charleston, S. C.	May 1, 1922
Gideon, Abraham, C.E. Mgr. Metropolitan Water Distr., Manila, P. I.	June 8, 1909

GIDLEY, HENRY T. Supt. Fairhaven Water Co., Fairhaven, Mass.	May 23, 1923
GIESEY, JESSE K., C.E. Shrewsbury, Pa.	Sept. 30, 1919
GILCREAS, F. WELLINGTON. 49 Hall Ave., Watertown, Mass.	Apr. 4, 1924
GILCRIST, CHARLES B. Supt., Water Works, Newburgh, N. Y.	May 25, 1922
GILKISON, GEORGE F., M.D. Chf. Chst. Water Dept., 2019 E. 29th St., Kansas City, Mo.	Apr. 24, 1920
GILLESPIE, C. G. Director, State Bd. Hlth., Bur. San. Engr., 336 40th St., Oakland, Calif.	June 10, 1911
GILLIG, JOHN T. Engineer, 910 Fayette Bank Bldg., Lexington, Ky.	July 28, 1924
GITCHELL, H. M. Supt. Water Works, Binghamton, N. Y.	May 7, 1924
GIVEN, CHARLES W. Supt., Water Works, Monrovia, Calif.	June 8, 1922
GLACE, IVAN M. Dist. Engr., Pa. Dept. of Hlth., 22 S. 22nd St., Harrisburg, Pa.	Nov. 30, 1921
GLADDING, R. D. P. O. Box 217, Wilson, N. C.	May 29, 1920
GLANNAN, PETER HUGH. Supt. Commonwealth Wtr. Co., W. O. Dvn., 22 Northfield Road, West Orange, N. J.	June 8, 1921
GLYNNE, HARRY N. 1676 Whitney Ave., New Haven, Conn.	Aug. 12, 1922
GODFROY, F. G. Supt. Wtr. & Lt., New Bern, N. C.	May 17, 1923
GOENTNER, WILLIAM B. 221 W. Mt. Carmel Ave., Glenside, Pa.	June 8, 1909
GOLDSMITH, CLARENCE. Asst. Chf. Engr., Natl. Bd. Fire Underwriters, Room 401, 209 W. Jackson Blvd., Chicago, Ill.	Dec. 27, 1915
GOLDSTEIN, MAURICE. Junior C. E., Water Dept., 212 N. Collington Ave., Baltimore, Md.	June 9, 1922
GOOD, TIMOTHY W. Supt. Water Works, Cambridge, Mass.	Feb. 7, 1920
GOODELL, J. E. Chmst., 444 Woolworth Bldg., Lancaster, Pa.	Apr. 14, 1924
GOODELL, J. M., H.E. 106 Lorraine Ave., Upper Montclair, N. J.	Apr. 27, 1894
GOODMAN, ARNOLD H. San. Engr., 1434 E. 65th Place, Jackson Park Station, Chicago, Ill.	Dec. 23, 1921
GOOGINS, A. L. San. Engr. 332 Lindenwood, Topeka, Kans.	Jan. 31, 1923
GOODNOUGH, X. HENRY. Chief Engr. Dept. of Public Health, Room 141, State House, Boston, Mass.	Feb. 2, 1924
GORDON, Fred G. Hyd. Engr., c/o D. H. Maury, 1445 Monadnock Block, Chicago, Ill.	June 8, 1921
GORE, WILLIAM. Cons. Engr., Confederation Life Bldg., Toronto, Ont.	May 30, 1910
GORMAN, ARTHUR E. San. Engr., Department of Health, 1121 Morse Ave., Chicago, Ill.	Mar. 25, 1924
GOSLAU, JUSTUS. Cedar Grove, N. J.	May 13, 1924
GOUDEY, RAY F. San. Engr., 821 Pacific Finance Bldg., Los Angeles, Cal.	Apr. 30, 1918
GOULD, HARRY W. Supt. Pmpg. Stn., Water Works Park, Detroit, Mich.	Mar. 20, 1922
GOULD, RICHARD H. Sanitary Engineer, 140 Nassau St., New York, N. Y.	Feb. 6, 1924
GRAF, AUGUST V. Chief Chemist, St. Louis Water Works, 34 East Grand Ave., St. Louis, Mo.	June 15, 1914
GRAFF, HANS, JR. Engr. U. S. Army Engrs., 3350a 23rd St., San Francisco, Cal.	Oct. 30, 1920
GRAHAM, GEORGE A. C.E., Nelson Bldg., Orange Ave., Daytona, Fla.	Dec. 11, 1919
GRAHAM, JAMES W. 16 Casco St., Portland, Me.	June 4, 1912
GRANT, ALEXANDER, C.E. 6 Queensgate, Inverness, Scotland.	Dec. 27, 1920
GRANTHAM, C. M. Supt. Water Dept., Goldsboro, N. C.	Jan. 6, 1916
GRAY, WILLIAM J. Supt. & C.E., Springfield City Water Co., Post Box 292, Springfield, Mo.	Apr. 23, 1924

Greeley, Samuel A. No. 6 N. Michigan Ave., Rm. 1710, Chicago, Ill. .... July 11, 1907
Green, F. W. Supt. Filtration & Pumping, Passaic Consolidated Water Co., Little Falls, N. J. .... Dec. 22, 1915
Green, George W. Supt., Stamford Township Water Works, Niagara Falls, Ont. .... Apr. 6, 1920
Green, Paul Evans. Civil and Sanitary Engineer, 400 N. Michigan Ave., Chicago, Ill. .... Apr. 14, 1915
Green, Ralph H. Morrison, Ill. .... Sept. 12, 1924
Greenalch, Wallace. C.E., 37 So. Pearl St., Schuylerville, N. Y. .... July 18, 1917
Gregory, John Herbert. Cons Engr., Prof. Civ. and San. Eng., The Johns Hopkins Univ., Baltimore, Md. .... Apr. 1, 1910
Griffey, H. A. Mgr. Water Dept., City Hall, Janesville, Wis. .... June 14, 1920
Griffiths, Geo. E. C.E., 365 E. 197th St., New York, N. Y. .... Mar. 25, 1924
Grimes, Edwin L. Engr., J. B. McCrary Eng. Corp., 44 Vedado Way, Atlanta, Ga. .... Feb. 23, 1920
Grimmer, Allan K. Town Engineer, Riordon Company, Limited, Temiskaming, Que. .... June 2, 1920
Grobbel, Daniel Cornelius. Asst. Secty., Bd. Wtr. Comnrs., Detroit, Mich. .... Oct. 17, 1920
Groeniger, William C. Cons. San. Engr., Michigan & Buttles Aves., Columbus, O. .... May 8, 1922
Groner, E. C. 4300 W. Lake St., Chicago, Ill. .... Oct. 11, 1923
Gross, C. P. Mgr., Water & Electric Dept., Box 87, Wisconsin Rapids, Wis. .... July 31, 1924
Grotz, William H. Assistant Engr. Bureau of Water, 50 Lake View Ave., Buffalo, N. Y. .... June 8, 1921
Gruetzmacher, Clarence S. 2108 26th St., Milwaukee, Wis. .... June 5, 1920
Gunning, Harrison, B.E. c/o Eberly & Stebinger, Sec. K., 560 Avenida de Mayo, Buenos Aires, A. R. .... Nov. 20, 1919
Gushee, Edward G. 2nd. Asst. Eng., Bureau of Water, 2122 N. 28th St., Philadelphia, Pa. .... May 12, 1908
Gutteridge, A. Gordon. San. Engr., Dept. Health, 51 Spring St., Melbourne, Australia .... May 17, 1923
Gwinn, Dow R. Terre Haute, Ind. .... Sept. 7, 1893

Habermeyer, George Conrad. Civil and Sanitary Engr., 57 Chemistry Bldg., Urbana, Ill. .... Apr. 14, 1915
Hackett, Lew E. 313 N. Capitol Ave., Lansing, Mich. .... May 28, 1924
Hale, Charles. Divnl. Supt. Water Works, 452 St. Antoine St., Montreal, Canada .... Apr. 24, 1920
Hale, Frank E., Ph.D. Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y. .... May 12, 1908
Hale, Richard A. Chief Engineer, Essex Company, Lawrence, Mass. .... May 28, 1924
Hale, Richard King, C.E. 545 Chestnut Hill Ave., Brookline, Mass. .... June 10 1911
Haley, Daniel F. 239 Westervelt Ave., New Brighton, S. I., N. Y. .... Mar. 19, 1924
Hall, H. F. Chf. Engr., Water Works Dept., Northern Apts., Sarnia, Ont. .... June 21, 1920
Hall, H. G. Supt. Pub. Util. Comn., Ingersol, Ont. .... Mar. 26, 1923
Hall, Harry R. Dpty. Chf. Engr., Washington Suburban Sanitary District, Hyattsville, Md. .... May 8, 1915
Hall, Warren E. Dist. Eng. U. S. Geological Survey, 6 Government St., Asheville, N. C. .... Dec. 8, 1923
Hallers, John A. Chst., Ind. Svce. Corp. of Va., 4 Dynamite Ave., City Point, Va. .... Apr. 27, 1922

Halpin, George R. 703 16th St., Watervliet, N. Y. .... June 13, 1916
Halpin, Thomas F. c/o A. P. Smith Mfg. Co., East Orange, N. J. .... July 18, 1901
Hammerly, Fred V. 536 Call Bldg., San Francisco, Calif. .... Jan. 2, 1924
Hammond, R. B. Supt. Water Dept., Blue Island, Ill. .... June 8, 1919
Hammond, W. H. Supt., Lindsay Water Works, Lindsay, Ont., Can. .... June 24, 1914
Hancock, Edwin. Cons. Engr., 2047 Ogden Ave., Chicago, Ill. Nov. 12, 1919
Hanna, David McLean. Supt. of Water Works, City Hall, Windsor, Ont. .... June 9, 1920
Hannan, Frank. Chst., Fltn. Plant, 181 Willow Ave., Toronto, Ont. .... July 30, 1921
Hansen, A. E. Hyd. and San. Engr., 116 W. 39th St., New York, N. Y. .... Dec. 31, 1917
Hansen, J. C. Water Works Trustee, 551 West Broadway, Council Bluffs, Iowa .... Feb. 27, 1924
Hansen, Paul. c/o Pearse, Greeley & Hansen, No. 6 N. Michigan Ave., Rm. 1710, Chicago, Ill. .... June 4, 1912
Harder, H. J. Civ. & San. Engr., 129 Market St., Paterson, N. J. .... Dec. 4, 1920
Harding, George. Mgr., 1105 Paulsen Building, Spokane, Wash. .... Oct. 10, 1912
Harding, James C., C.E. 170 Broadway, New York, N. Y... July 12, 1922
Harding, James C., Jr., C.E. 170 Broadway, New York, N. Y. .... June 6, 1922
Harding, John H. Supt. Water Works, La Porte, Ind. .... May 14, 1918
Harding, Robert J. Vice Prest., San Antonio Water Supply Co., 106 Market St., San Antonio, Texas .... Oct. 23, 1914
Hardy, Edward Dana. Asst. Engr., United States Engineer Office, Room 250, Old Land Building, Washington, D. C. .... May 12, 1908
Harper, L. V. Mgr., Chelan Electric Co., Chelan, Wash. .... Aug. 19, 1914
Harris, F. M. Supt. Water Works, Odessa, Mo. .... Aug. 5, 1924
Harris, R. C. Com'r of Works, City Hall, Toronto, Ont., Can. .... May 12, 1914
Harrison, John H. Supt. Kingston Wtr. Wks. Dept., City Hall, Kingston, N. Y. .... Mar. 19, 1924
Harrison, Ronald. B. A. Sc., Engr. & Supt. Scarboro Twnshp. Water Works, Birch Cliff, P. O. Toronto, Canada .... Jan. 30, 1924
Harrub, C. Nelson. San. Engr., 506 Fourth & First Ntl. Bnk Bldg., Nashville, Tenn. .... Apr. 16, 1914
Harshbarger, Elmer Dwight. Pres., Pitt Construction Co., 239 Gladstone Rd., Squirrel Hill, Pittsburgh, Pa. Sta... June 28, 1924
Haskins, Capt. Chas A. Consulting Engineer, 517 Finance Bldg., Kansas City, Mo. .... June 19, 1924
Hasskarl, Joseph F. Cons. Engr., 1934 North Broad St., Philadelphia, Pa. .... Mar. 8, 1924
Hassler, Dr. Samuel F. Supt. Public Safety, 500 No. Second St., Harrisburg, Pa. .... May 29, 1920
Hatch, Donald M. Chf. Engr. Water Dept., 506 First St., Jackson, Mich. .... May 16, 1920
Hatfield, William Durrell. Sewage Disposal Plant, Sanitary District of Decatur, Decatur, Ill. .... Jan. 31, 1917
Hatton, T. Chalkley. Chief Engineer, City Hall, Milwaukee, Wis. .... June 11, 1902
Haupt, B. W. Secty., Roaring Creek and Bear Gap Wtr. Cos., 204 E. Sunbury St., Shamokin, Pa. .... Mar. 16, 1922
Havill, Harold Thomas. Asst. Engr., Dept. Wtr. Sup. New York City, 51 North St., Mt. Vernon, N. Y. .... June 11, 1902

Hawley, George W. Secty. and Treasr. Water Co., Dixon, Ill. ... June 21, 1920
Hawley, Geo. W. Engr. in Charge, Water Supply Investgn. & Constn., East Bay Water Company, Oakland, Cal. ... June 30, 1922
Hawley, John B. Cons. Engr., 403 Cotton Exchange, Ft. Worth, Tex. ... June 1, 1923
Hawley, W. C. Chf. Engr. and Genl. Supt., Pennsylvania Water Co., 712 South Ave., Wilkinsburg, Pa. ... Apr 27, 1910
Haydock, Charles. Engr., Water Companies, 922 Commercial Trust Bldg., Philadelphia, Pa. ... Feb. 17, 1919
Hayes, James G. Supt. of Water Works, Smith Falls, Ont., Canada ... Mar. 8, 1924
Hayes, Oscar C. Asst. Engr., Board of Water Supply N. Y. C., Prattsville, N. Y. ... Mar. 19, 1924
Hayford, B. B. Superintendent Water Works, Waukesha, Wis. ... June 8, 1909
Hays, C. D. Huron, South Dakota ... Oct. 31, 1922
Hazen, Allen. Civil Engineer, 25 W. 43rd St., New York, N. Y. ... May 27, 1896
Hazlehurst, George H. Chf. San. Eng., Montgomery, Ala. Nov. 1, 1914
Healey, Thomas. Supt. Davenport Water Co., 206 Kahl Bldg., Davenport, Iowa ... May 28, 1924
Heard, Albert. Supt. and Treas., Hagerstown, Md. ... July 18, 1907
Heath, Ray. Laboratories of Dept. of Health, City Hall, Toronto, Canada ... June 26, 1924
Hebbring, A. W. Supt. Wauwatosa Water Works, 292 Keyyon Ave., Wauwatosa, Wis. ... Sept. 8, 1923
Hechmer, Carl A. Dept. Engr., Mtnce. and Optg. Dept., Wash. Subn. San. Dist., Hyattsville, Md. ... Nov. 3, 1919
Heermans, H. C. Manager Water Works Co., Hoquiam, Wash. ... June 26, 1886
Heffernan, David A. Supt. Water Dept., Milton, Mass. ... May 28, 1924
Helling, Harry A. Supt., Consol. Water Co., 86 Beekman St., North Tarrytown, N. Y. ... Jan. 17, 1922
Henby, Wm. H. Secty. and Mgr., West St. Louis Water and Light Co., 6600 Delmar Ave., St. Louis, Mo. ... May 6, 1915
Henderson, Charles R. Mgr. Davenport Water Co., Davenport, Iowa ... June 18, 1901
Henderson, Thomas. Supt. Water Bureau, City Hall, Yonkers, N. Y. ... Apr. 23, 1924
Hendrick, Wallace M. 11 Clarkson Ave., Brooklyn, N. Y. ... May 10, 1915
Hendricks, R. W. Engr. Hyd. Dept. Indtrs. Labs., 207 E. Ohio St., Chicago, Ill. ... Apr. 2, 1923
Hendry, W. A. Chf. Engr., Water Works, 628 West 9th St., Waterloo, Ia. ... Nov. 25, 1921
Henry, Warren, M.E. Ill. Com. Comn., 2061 S. Fourth St., Springfield, Ill. ... Apr. 3, 1922
Henshaw, Franklin. Supt. Wtr. Wks., Scarsdale, N. Y. Sept. 21, 1920
Herbert, E. H. Chf. Engr. Pumping Dept. of Water., Norfolk, Va. ... May 15, 1922
Herr, J. O. Sec. & Tr. Atlantic County Co., of N. J., Lock Box F, Pleasantville, N. J. ... June 5, 1916
Hess, Edwin Wesley. Cons. Engr., 2–6 Murray Bldg., Clearfield, Pa. ... Jan. 16, 1920
Hetzer, Mentor. Mgr. Moundsville Water Co., Moundsville, W. Va. ... Nov. 17, 1916
Heyward, T. C., B.S. Mech. & Elect. Engr., 1100 Realty Bldg., Charlotte, N. C. ... June 22, 1923
Hezzelwood, Lawrence Lyman. Engr., Des Moines Munic. Water Plt., 1003 Locust St., Des Moines, Iowa ... Aug. 13, 1924

Hibbs, Albert S. Ass't Supt., Akron City Water Works, 102 E. Mill St., Akron, Ohio	Sept. 12, 1922
Hibschman, Charles A. Supt., Ambler Springs Water Co., Ambler, Montgomery Co., Pa	Aug. 11, 1924
Hicks, J. S. Superintendent Water Co., Berwick, Pa	Dec. 8, 1910
Higgins, Lafayette, C.E. San. Engr. State Bd. of Health, 1144 W. 25th St., Des Moines, Ia	Dec. 10, 1915
Highland, Scotland G. General Manager, Clarksburg Water Board, Clarksburg, W. Va	Feb. 10, 1913
Hill, Albert B. Cons. C.E., 100 Crown St., New Haven, Conn	Oct. 30, 1914
Hill, John W. Consulting Engineer, 45–47 Bodmann Bldg., Cincinnati, Ohio	June 26, 1886
Hill, Nicholas S., Jr. Cons. Engr., 112 E. 19th St., New York, N. Y	June 18, 1901
Hilton, Frank L. Mgr., Los Angeles Branch, Water Works Sup. Co., 305 N. Stoneman Ave., Alhambra, Calif	Jan. 16, 1924
Hinchman, T. H. Cons. Engr., 800 Marquette Bldg., Detroit, Mich	June 1, 1923
Hineman, James. 40 E. 9th St., Newport, Ky	Feb. 16, 1924
Hinman, Jack J., Jr. Chf. Water Lab. State Bd. Hlth., P. O. Box 313, Iowa City, Ia	Apr. 21, 1915
Hoad, Prof. William Christian. 1028 Martin Place, Ann Arbor, Mich	June 24, 1913
Hoag, George F. Fire Prevention Engr., 76 William St., New York, N. Y	June 2, 1920
Hoag, Percy LaTourette. Hyd. Engr., Manhasset, L. I., N. Y.	June 28, 1919
Hoagland, Ira Gould. Secty., National Automatic Spklr. Assn., 80 Maiden Lane, New York, N. Y	Apr. 27, 1910
Hodges, George C. Chemist, Consolidated Water Co., 712 Washington St., Utica, N.Y	June 11, 1924
Hodgkins, H. C. Civil Engineer, 415 Dillaye Bldg., Syracuse, N. Y	Apr. 18, 1888
Hodgman, Burt B., C.E. 50 Church St., New York, N. Y	July 18, 1907
Hodkinson, Thomas. C.E., Supt. Water Works, 14 King St., London, Ont., Can	Apr. 15, 1913
Hoffmaster, George Edward. 44 Bay View Ave., New Rochelle, N. Y	May 13, 1916
Hogan, John Philip. Cons. Engr., 13 East 11th St., New York, N. Y	June 9, 1920
Holbrook, Arthur R., C.E. c/o Fuller & Maitland, Rm. 206, Walsix Bldg., Kansas City, Mo	Apr. 30, 1923
Holbrook, Royal H. Comb. Engr., Ia. State College, 1420 Second Ave., Cedar Rapids, Ia	Sept. 8, 1919
Holden, Charles A., C.E. Dctr., Thayer Sch. of Civ. Eng., Hanover, N. H	Oct. 21, 1919
Holdredge, Neil C. Asst. Chief, North Jersey District Water Supply Commission, P. O. Box 615, Haskell, N. J.	May 26, 1924
Holland, Ray Kingsbury. Consulting Engineer, 106 E. Liberty St., Ann Arbor, Mich	Jan. 17, 1919
Hollingsworth, R. S. Supt. Water Dept., Asheville, N. C	Dec. 8, 1923
Holman, E. T. Chief Inspector, Tenn. Inspect. Bur., 1034 Stahlman Bldg., Nashville, Tenn	Jan. 7, 1924
Holmes, A. G. P. O. Box 1200, East Pittsburgh, Pa	July 10, 1906
Holmes, M. G. Supt. Water Works, Mitchell, S. D	Aug. 16, 1918
Holmquist, C. A. State Dept. of Health, Albany, N.Y	Apr. 27, 1923
Holway, A. S. Holway Eng. Co., Wright Bldg., Tulsa, Okla.	June 9, 1921
Hommon, Harry B. San. Engr., U. S. P. H. S., 76 New Montgomery St., San Francisco, Cal	July 27, 1921
Honness, George Gill. Grand Gorge, N. Y	Apr. 4, 1924

Hooper, Thomas H. Supt. Water Works, Winnipeg, Manitoba, Canada........ Mar. 5, 1924
Hoopes, Edgar M., Jr. Water Comnr., Box 895, Wilmington, Del........ Apr. 10, 1923
Hoover, Charles P. Chemist, Filtration Plant, Columbus, Ohio........ May 14, 1913
Hoover, Clarence B. Supt. Wtr. & Swge. Disp., 6th and Broad Sts., Columbus, Ohio........ Apr. 18, 1923
Hopkins, Charles Comstock. Hydraulic and Sanitary Engr., 349 Cutler Building, Rochester, N. Y........ June 10, 1911
Hopkins, Edward S. MontebelloFilters, Hillen Road, Baltimore, Md........ June 13, 1921
Hopkins, Franklyn C. Prest. Consol. Water Co., 712 Washington St., Utica, N. Y........ June 16, 1919
Hopkins, Newton F. Civil Engineer, 801 Home Trust Bldg., Pittsburgh, Pa........ July 18, 1907
Hopper, Walter C. Supt. Acquackanonk Water Co., 145 Prospect St., Passaic, N. J........ June 10, 1911
Horn, J. F. Prest. Water Co., Vandergrift, Pa........ Oct. 10, 1919
Horne, Alfred Dewey. Supt. Water and Lt. Comn., Fairmont, Minn........ Nov. 12, 1920
Horner, Charles M. Supt. Water Works Co., 1705 State St., East St. Louis, Ill........ June 24, 1903
Horrigan, William J. Consulting Engineer, Realty Bldg., Louisville, Ky........ July 26, 1921
Horton, Robert E., H.E. R. D. 1, Voorheesville, N. Y........ Jan. 20, 1911
Horton, Theodore. Chf. San. Engr. Dept. of State Engineering, 346 State St., Albany, N. Y........ July 18, 1907
Hough, Laurence C. Dist. Mgr. Pitometer Co., 55 Bourne St., Jamaica Plain, Mass........ Jan. 17, 1919
Houston, L. J., Jr. City Mgr., Fredericksburg, Va........ Feb. 17, 1919
Howard, Charles D. Chemist, State Bd. of Hlth., Concord, N. H........ Feb. 18, 1921
Howard, John L. Ashburton Place, Boston, Mass........ May 31, 1924
Howard, N. J. Bact. in Chge., Filtn. Plant Labty., Centre Island, Toronto, Ont........ June 21, 1920
Howe, M. J. Supt., Bd. Water Comnrs., Lake City, Minn........ Feb. 11, 1922
Howell, David J., C.E. Union Trust Building, Washington, D. C........ Oct. 10, 1914
Howell, Fred B. Bd. of Wtr. Comnrs., Medina, N. Y........ July 20, 1920
Howes, D. W. C.E., 3100 Stuart Ave., Richmond, Va........ May 25, 1922
Howland, E. Robert, R.E. c/o The British Pitometer Co., 39 Victoria St., London, S. W. I., England........ Apr. 22, 1914
Howland, J. Hastings. Engineer, National Board of Fire Underwriters, 76 William St., New York, N. Y........ May 15, 1924
Howson, Louis R. Alvord, Burdick & Howson, 130 Eighth Ave., LaGrange, Ill........ Apr. 24, 1916
Hoy, Joseph A. Asst. Genl. Foreman, Water Dept., 18 East Worcester St., Worcester, Mass........ May 15, 1922
Hubbell, Clarence W. Cons. Engr, 2348 Penobscot Building, Detroit, Mich........ June 24, 1903
Hudson, John. Compania Aguas Corrientes, San Nicolas, F. C. C. A., A. R........ Aug. 19, 1924
Hudson, Leo. Cons. Engr., 705 Fifth Ave., Arcade Bldg., Pittsburgh, Pa........ July 7, 1913
Huggans, R. D. Mgr. Water Works, Streator, Ill........ Apr. 19, 1915
Hunt, Wm. G. Pump House Residence, R. R. No. 4, Peterborough, Ont., Can........ Apr. 29, 1924
Hunter, Charles A., Asst. Dctr. State Hlth. Labty., Vermilion, S. Dak........ July 18, 1923

HUNTER, GEORGE A. 512 16th Street, Oakland, Calif.	Aug. 28, 1922
HUNTER, HENRY G. 598 Union Ave., Montreal, Canada.	June 10, 1911
HUNTER, T. B. Consulting Engineer, 505 Rialto Building, San Francisco, Cal.	July 10, 1906
HUNTER, W. B. Div. Engr., Board of Water Supply N. Y. C., Prattsville, N. Y.	Mar. 12, 1924
HUNTER, W. W. Supt., Canal & Water Works, Augusta, Ga.	May 24, 1922
HURD, CHARLES H. 1405 Merchants Bank Bldg., Indianapolis, Ind.	Aug. 11, 1914
HURLBUT, WILLIAM W. 207 South Broadway, Los Angeles, Calif.	May 28, 1924
HURTGEN, P. J. Dctr. Pub. Wks., City Hall., Kenosha, Wis.	May 21, 1923
HUTCHINS, WILL A. Secty. and Supt. Water Co., 196 Van Buren St., Freeport, Ill.	Nov. 30, 1920
HUTCHINSON, ALEXANDER, C.E. Dctr. Drummond, McCall and Co., P. O. Box 660, Montreal, P. Q.	May 5, 1921
HUTSON, A. CARY. 76 William St., New York, N.Y.	Apr. 29, 1924
HUTTON, HAROLD S. San. Engr., Rm. 341 Oliver Bldg., Pittsburgh, Pa.	Apr. 1, 1920
HUY, HARRY F. Genl. Mgr., Western New York Water Co., 704 Electric Building, Buffalo, N. Y.	Apr. 13, 1916
HYDE, CHARLES GILMAN. Cons. Hyd. and San. Engr., Prof. San. Eng., Univ. of Cal., Berkeley, Cal.	July 18, 1907
HYMAN, H. H. Mgr. Miami Water Co., Miami, Fla.	Apr. 16, 1916
INMAN, C. E. Comnr. and Supt. Water Works, Warren, O.	May 24, 1921
INOUE, S. 290 Harajiku, Tokyo, Japan.	July 18, 1907
ISAAC, F. N. Sec. and G. M., The Hanford Water Co., Hanford, Cal.	May 12, 1908
IWASAKI. TOMI. Water Wks. Dept., Suido Kakucho, Tokyo-Shiyakusho, Japan.	Jan. 9, 1923
JACKSON, C. B. Supt. City Water Corpn., Fresno, Cal.	Aug. 18, 1920
JACKSON, DANIEL D. San. Expt., Havemeyer Hall, Columbia University, New York, N. Y.	Jan. 31, 1910
JACKSON, H. W. Supt. Water Works, 912 Arctic St., Antigo, Wis.	Aug. 7, 1924
JACKSON, JOHN F. Supt. Water Works Dept., 115 W. Fourth St., Rochester, Mich.	May 23, 1923
JACOBS, JOSEPH. Cons. C. E., 613–616 Thomson Bldg., Seattle, Wash.	July 30, 1920
JACOBS, S. WILLARD. Chem. Engr., 9 East 41st St., New York, N. Y.	Feb. 5, 1919
JACOBSEN, ROBERT T. City Engr., Fargo, N. D.	Apr. 16, 1914
JAEGER, C. P. Commissioner, Water Dept., City Hall, Cleveland, Ohio.	June 11, 1924
JANZIG, ALEXANDER C. Wtr. Bact. & Chst. Filtn. Plant, 904 20th Ave., S. E., Minneapolis, Minn.	Oct. 11, 1921
JARVIS, CAPT. ALEXANDER CHARLES. Osterbrogade 40, Copenhagen, Denmark.	May 5, 1914
JENKINS, DAVID. c/o The New Jersey Zinc Co., Franklin, N. Y.	Oct. 14, 1922
JENKINS, W. H. M. Superintendent of Water Works, Franklinton, N. C.	Dec. 8, 1923
JENKS, HARRY N. 2020 X St., Sacramento, Calif.	Jan. 26, 1917
JENNE, LYLE L. Sanitary Engr., Bureau of Water, 795 City Hall, Philadelphia, Pa.	June 30, 1921
JENNINGS, CHARLES A. 1339 Monadnock Bldg., Chicago, Ill.	May 12, 1908
JENSEN, J. ARTHUR. Supervisor Water Works Dept., Minneapolis, Minn.	Apr. 15, 1910

Jensen, J. Chris. Municipal Water Works, Council Bluffs, Ia.	June 3, 1912
Jeup, B. J. T. Chf. Engr., Ind. Water Co., 113 Monument Circle, Indianapolis, Ind.	Feb. 22, 1920
Jewell, Albert H. Executive Sect., Health Conservation Assoc., 405 Hall Bldg., 9th & Walnut Sts., Kansas City, Mo.	Apr. 15, 1921
Johns, Herbert M. Supt., Hanford Water Co., Hanford, Cal.	Oct. 17, 1920
Johnson, Edgar W. Asst. Engr., Water Dept., 3821 Elliot Ave., Minneapolis, Minn.	July 13, 1917
Johnson, George A. Cons. Engr., 150 Nassau St., New York, N. Y.	July 18, 1907
Johnson, H. E. Supt. Public Utility Plant, Winona, Miss.	Dec. 22, 1912
Johnson, R. F. 217 Hanchett St., Saginaw, Mich.	May 23, 1923
Johnson, Samuel C. Room 204, Union Station, Little Rock, Ark.	Apr. 9, 1923
Johnson, W. Scott. Division of Sanitary Engineering, State Board of Health, Jefferson City, Mo.	Feb. 16, 1924
Johnston, William J. Supt. Water Works, Marquette, Mich.	Mar. 10, 1917
Johnstone, Alan M. E., C.E. San. and Hyd. Engr., 2124 Ellis Ave., New York, N. Y.	June 16, 1919
Jones, A. J. Prest. New Brunswick Trust Co., New Brunswick, N. J.	Apr. 16, 1884
Jones, Allen A. Res. Engr. Fuller & McClintock, c/o City Water Dept., Fairmont, W. Va.	Feb. 23, 1924
Jones, Frank Woodbury. Sanitary Chemist, 14214 Miles Ave., Cleveland, Ohio	May 23, 1923
Jones, H. Seaver. V. Prest., East Jersey Pipe Co., 7 Dey St., New York, N. Y.	July 16, 1922
Jones, Harvey P. Mgr. Toledo Office, Fuller & McClintock, 319 Summit-Cherry Bldg., Toledo, O.	July 30, 1922
Jones, Hiram F. Supt. Pumping & Filtration, Elmira Water Board, Elmira, N. Y.	July 18, 1907
Jones, J. M. Bristol and Warren Water Works, Bristol, R. I.	May 9, 1916
Jones, W. G. Box 1114, Raleigh, N. C.	Oct. 18, 1923
Jones, W. T. Superintendent Water & Light Department, Lexington, N. C.	Dec. 11, 1922
Jones, William Allen. 230 Belmont Ave., Detroit, Mich.	Nov. 8, 1920
Jones, William Clayton. 426 Market St., Camden, N. J.	May 14, 1914
Jones, William Nelson. C.E., 806½ Florabraska Ave., Tampa, Fla.	Apr. 14, 1914
Jordan, Frank C. Secy. Indianapolis Water Co., 113 Monument Circle, Indianapolis, Ind.	June 10, 1911
Jordan, Harry E. San. Engr., Water Co., 113 Monument Circle, Indianapolis, Ind.	Oct. 7, 1919
Judson, John W. Chf. Acct. Dpt. Sts. and Pub. Impvts., Newark, N. J.	June 12, 1920
Jutz, Charles E. Treasr. W. St. L. Water and Lt. Co., 6600 Delmar, St. Louis, Mo.	Apr. 12, 1920
Kable, Edgar P. Genl. Mgr. York Water Co., 42 East Market St., York, Pa.	Nov. 10, 1917
Kappler, William F. Prin. Asst. Engr., Dvn. of Wtr., Newark, N. J.	Dec. 23, 1921
Kastberg, Karl C. City Engineer, Box 923, Des Moines, Ia.	June 7, 1904
Kay, Edgar B. Chf. Hyd. & San Branch., Q. M. C., 1400 Fairmont St., N. W., Washington, D. C.	Apr. 27, 1910
Kayanoki, Hiroyuki. City Planning Bureau, Dept. of Home Affairs, Tokio, Japan	June 30, 1923

KEATING, CHARLES STANLEY. Asst. Engr., Bureau of Water, Syracuse, N. Y. .... May 16, 1919
KEEFER, CLARENCE EDWARD. Asst. Dsng. Engr., Sewer Dvn., City Hall Annex No. 1, Baltimore, Md. .... Feb. 23, 1920
KEILS, ANTHONY. Supt., Mt. Clemens Water Works, 38 Moross Ave., Mt. Clemens, Mich. .... June 8, 1909
KEITH, J. CLARK. Chf. Engr., Essex Border Util. Comn., 302 Ouellette Ave., Windsor, Ont. .... Mar. 21, 1923
KELIHER, TIMOTHY. Supt. Williamsport Water Co., Williamsport, Pa. .... Feb. 15, 1917
KELLEY, C. H. Supt. Whichita Water Co., 301 No. Main St., Wichita, Kans. .... July 5, 1924
KELLNER, HUGH. Chf. Engr. City Water Works, 74 Moy Ave., Windsor, Ont. .... Feb. 28, 1923
KELLOGG, JAMES WILFORD. Bct. and Chst., State Lab. of Hyg., Raleigh, N. C. .... June 10, 1921
KELLY, ROBERT D. Engr., N. Y. Fire Ins. Rtg. Orgzn., 700 Gurney Bldg., Syracuse, N. Y. .... June 8, 1921
KELSEY, J. W. Genl. Supt. Bureau of Water, St. Paul, Minn. May 13, 1913
KEMBLE, F. T. Secty. New Rochelle Water Co., 238 Main St., New Rochelle, N. Y. .... June 24, 1915
KEMPKEY, AUGUSTUS. Cons. Engr., 416 Hobart Bldg., San Francisco, Cal. .... June 10, 1923
KENDALL, THEODORE REED. Eng., Editor, *The American City*, 303 So. Broadway, South Nyack, N. Y. .... Mar. 13, 1919
KEOGH, WM. J. Asst. Engr. Dept. of Water, 9350–209th St., Queens, N. Y. .... June 13, 1922
KERN, PETER. Mgr. Water Dept., Fort Madison, Ia. .... Aug. 31, 1917
KIEF, ROBERT F. Civil Engineer, 7512 Seventh Ave., Brooklyn, N. Y. .... Apr. 4, 1924
KIENLE, JOHN A. San. Engr., 25 W. 43rd St., New York, N. Y. June 8, 1909
KILLAM, SAMUEL E. Supt. Distbn. Sctn. Wtr. Divn., 1 Ashburton Place, Boston, Mass. .... Nov. 25, 1915
KIMBALL, FRANK C. 2 DeBarry Place, Summit, N. J. .... June 11, 1902
KIMBERLEY, A. ELLIOT. San. Engr., 8 East Long St., Columbus, Ohio .... May 23, 1923
KING, ARNOTT CHISWELL. 145 Hamilton Ave., Paterson, N. J. Apr. 20, 1921
KING, KENNETH K. 206 Walsix Bldg., Kansas City, Mo. .... Dec. 12, 1923
KINGMAN, HORACE. Comr. and Supt., City Hall, Brockton, Mass. .... Mar. 17, 1916
KINGSLEY, JOHN F. Supt. Water Works, Covington, Ky. .... June 9, 1920
KINTER, S. G. Supt., Wtr. Co., Jersey Shore. Pa. .... May 24, 1922
KIRCHOFFER, WILLIAM GRAY. San. & Hyd. Engr., 22 N. Carroll St., Madison, Wis. .... Jan. 31, 1923
KIRK, CLARENCE L. Prest. Indianapolis Water Co., 113 Monument Place, Indianapolis, Ind. .... June 8, 1907
KIRKPATRICK, WALTER G. Cons. Hyd. Engr., University, Miss. .... Apr. 27, 1910
KITCHEN, H. B. Mgr. Watsonville City Wtr. Wks., 31 E. 3rd St., Watsonville, Calif. .... Feb. 16, 1924
KIVELL, WAYNE A. Sanitary Engineer, The Dorr Co., 247 Park Ave., New York, N. Y. .... May 28, 1924
KLAPP, CARL F. Supt. Water Works, Everett, Wash. .... Oct. 7, 1917
KLARE, R. W. Mgr., Wabash Water and Light Co., Wabash, Ind. .... June 24, 1915
KLAUS, FRED J. Asst. Engr., East Bay Water Co., 2414 Dana St., Berkeley, Cal. .... Oct. 2, 1915
KLEIN, FEDERICO. Cia Alumbrado Electrico, San Salvador, C. A. .... Apr. 2, 1918

KLEIN, WILLIAM I. Cons. Engr., 21 Maple Terrace, East Orange, N. J.	July 1, 1913
KNEEN, A. H. Fox Bldg., 1612 Market St., Philadelphia, Pa.	Jan. 8, 1911
KNERR, C. B. Supt. Wtr. Wks., 37 East Broad St., Bethlehem, Pa.	May 23, 1923
KNICKERBACKER, JOHN, C.E. Prest. Eddy Valve Co., 86 First St., Troy, N. Y.	June 24, 1913
KNOUSE, HOMER V. Asst. Supt. and Purch. Agt., Met. Water Dist., 200 City Hall, Omaha, Neb.	Sept. 21, 1918
KNOWLES, CLARENCE R. Supt. Water Service, I. C. R. R., 6627 Woodlawn Ave., Chicago, Ill.	June 4, 1913
KNOWLES, MORRIS. Cons. Engr., 507 Westinghouse Bldg., Pittsburgh, Pa.	July 18, 1907
KNOX, STUART K. 10 Granada Place, Montclair, N. J.	June 8, 1909
KOHOUT, FREDERICK E. Supt., Short Hills Water Co., P. O. Box 291, Short Hills, N. J.	Aug. 1, 1923
KOON, RAY EMERSON. Stevens & Koon, Cons. Engrs., Spalding Bldg., Portland, Ore.	Feb. 11, 1922
KRIEGSHEIM, HEINRICH. c/o The Permutit Co., 440 Fourth Ave., New York, N. Y.	May 11, 1915
KUESTER, JOHN H. Supt. Wtr. Wks., 370 Naymut St., Menasha, Wis.	June 30, 1923
KUNIAK, W. A. Supt. & Engr., Water Works, 3201 North 20th St., Tacoma, Wash.	Aug. 27, 1924
KUNKLE, CHARLES W. Supt. Johnstown Water Co., 229 Mifflin St., Johnstown, Pa.	June 11, 1924
KUNZELMAN, HENRY P. 14317 Bayes Ave., Lakewood, Ohio.	Apr. 23, 1924
LAASE, WILLIAM F. 215 Myrtle Ave., Flushing, N. Y.	May 28, 1924
LABOON, JOHN F. Cons. Engr., 826 Bayridge Ave., Pittsburgh, Pa.	May 23, 1923
LACOUNT, H. O. Mgr., Inspn. Dept. Factory Mutual Ins. Co., 124 College Ave., West Somerville, Mass.	May 12, 1908
LAFLIN, ALBERT A. Supt. Water Works, St. Stephen, N. B.	June 10, 1920
LAFRENIERE, THEO. J. San. Engr., Board of Health of P. Q., 59 Notre Dame East, Montreal, Canada	June 24, 1916
LAMB, JAMES E. C. P. A., 301 Chestnut St., Harrisburg, Pa.	June 9, 1923
LAMBERT, URBAN S. President, Alexandria Water Co., Alexandria, Va.	Dec. 20, 1923
LAMEY, FRANK T. Supt. New Chester Water Co., 422 East 20th St., Chester, Pa.	May 11, 1921
LANDMAN, L. B. Supt. Capital City Water Co., Jefferson City, Mo.	Sept. 2, 1914
LANGLIER, WILFRED F. Assoc. Prof. San. Eng., Univ. of California, Berkeley, Cal.	Feb. 28, 1923
LANPHER, E. E. Division Supt., Bureau of Water, 412 City County Bldg., Pittsburgh, Pa.	Apr. 8, 1922
LARGE, H. LEE. Supt., Dept. of Health, Rocky Mount, N. C.	May 28, 1924
LARMON, FRANK P. Chf. Engr., Met. Water Dist., Omaha, Neb.	Apr. 17, 1914
LASSITER, A. D. Supt. Pub. Wks. & City Engr., Windsor, N. C.	May 17, 1923
LASSO, ALFREDO F. Ing. Civ., Obras Sanitarias de la Nacion, Buenos Aires, R. Argentina	Sept. 26, 1917
LAURIE, EDWARD. Cons. Engr., 243 Bleury St., Montreal, P. Q.	June 21, 1920
LAUTER, CARL J. Chief Chemist, Washington Filtration Plant, McMillan Park, Washington, D. C.	Apr. 13, 1922
LAUTZ, W. E. Secty. and Mgr., Pekin Water Works, Pekin, Ill.	Nov. 14, 1915

Lawlor, Francis D. H. Superintendent Citizens Water Co., Burlington, Iowa.......... July 10, 1906
Lawrence, E. A. Cons. Civ. and Munic. Engr., 511-12 Hartman Bldg., Columbus, Ohio.......... Apr. 6, 1921
Lawrence, Frederick H. Filtration Engineer, 145 W. Sharpnack St., Germantown, Philadelphia, Pa.......... Mar. 5, 1924
Lawrence, W. H. Supt. Water Works, Box 362, Kalispell, Mont.......... Dec. 16, 1919
Lawson F. W. Secty. Metropolitan Wtr. Supply Dept., 56 James St., Perth, West Australia.......... June 6, 1923
Lawton, Ralph W. 137 North Van Ness Ave., Los Angeles, Cal. July 10, 1906
Lea, William S. Consulting Engineer, 340 University St., Montreal, Canada.......... Jan. 26, 1924
Leach, J. J. Pres. & Gen. Mgr., Badger Meter Mfg. Co., 841-30th St., Milwaukee, Wis.......... Aug. 14, 1923
Learned, Albert P. Asst. Engr., with Black & Veatch, 701 Mutual Bldg., Kansas City, Mo.......... May 15, 1922
Ledden, Ernest M. 404 Fourth Ave., New York, N. Y.......... Apr. 5, 1912
Ledoux, J. W. Cons. Engr., 112 N. Broad St., Philadelphia, Pa.......... July 18, 1907
Lee, Charles H. Cons. Hyd. Engr., 58 Sutter St., San Francisco, Cal.......... Mar. 21, 1912
Leet, J. N. Supt. Water Dept., North East, Pa.......... May 4, 1911
Leisen, Theodore A. Gen. Mgr. Metropolitan Utilities Dist., 18th & Farnam Sts., Omaha, Nebr.......... June 7, 1904
Lendall, Harry N. Engineering Dept., Rutgers College, New Brunswick, N. J.......... Mar. 6, 1923
Lenhardt, Laurence G. City Engr., Pontiac, Mich.......... June 10, 1920
Leonard, W. D. Mgr., Water, Lt. & Gas Plant, 101 N. Main St., Ft. Atkinson, Wis.......... July 21, 1922
Leopold, F. B. 407 House Bldg., Pittsburgh, Pa.......... May 11, 1914
LeSage, Thomas William. Engr., Water Works Dept., City Hall, Montreal, Canada.......... Apr. 24, 1916
Leslie, James. Canada Fire Udtrs. Assn., Coristine Bldg., Montreal, Canada.......... May 5, 1920
Letton, Capt. H. P. Grant, Fulton and Letton, Engrs., 505 Bankers Life Bldg., Lincoln, Neb.......... Dec. 23, 1914
Levering, George S. Hydraulic Engr., Bureau of Water, City Hall, Philadelphia, Pa.......... May 24, 1922
Levine, Dr. Max. Assoc. Prof. Bactlgy., Iowa State College, Ames, Ia.......... Nov. 30, 1921
Levy, A. G. Engr. of Design, Div. of Water, 9405 Hough Ave., Cleveland, Ohio.......... May 17, 1910
Lewis, Chester F. Cons. Engr., c/o Spoon & Lewis, Box 990, Greensboro, N. C.......... Apr. 23, 1924
Lewis, John V. 67 Normandy Ave., Rochester, N. Y.......... Feb. 18, 1921
Libby, Frank D. Chst. Kalamazoo Vegetable Pchmt. Co., Kalamazoo, Mich.......... May 23, 1923
Lightfoot, J. C., Jr. N. J. Water Service Co., 1307 Real Estate Trust Bldg., Philadelphia, Pa.......... May 11, 1914
Lines, Walter H. Salesman, General Chemical Co., 515 Union Trust Bldg., Pittsburgh, Pa.......... July 31, 1924
Lira, Leonardo. Chf. Engr. of Inspt. Water Works, Casilla 492, Santiago, Chile.......... Sept. 9, 1919
Litch, M. B. Chst. in chge. of Filters, 631 Pine St., Steelton, Pa.......... May 1, 1922
Little, Beekman C. Supt. Water Works, 43 City Hall, Rochester, N. Y.......... June 24, 1903
Livezey, W. B. Prest., Newport News Lt. and Water Co., Newport News, Va.......... May 10, 1915

LOCHRIDGE, ELBERT E. Engineer Water Dept., P. O. Box 1238, Springfield, Mass. .... July 10, 1906
LOCKWOOD, WILBUR, D. C.E., 903 Second St., Peekskill, Peekskill, N. Y. .... Mar. 19, 1924
LOFTON, H. M. Chattanooga, Tenn. .... May 25, 1895
LOGAN, C. G. Supt. Waterworks, Waynesville, N. C. .... Dec. 8, 1923
LONEY, N. M. 51 Wall St., New York, N. Y. .... Mar. 31, 1924
LONG, GEORGE J. Prest., Inter-State Water Co., P. O. Box 2360, Louisville, Ky .... May 24, 1915
LONG, JAMES H. Chief Engr., City Hall, Camden, N. J. .... May 13, 1919
LONGLAND, E. L. Supt., Municipal Water District, San Rafael, Calif. .... Apr. 10, 1924
LONGLEY, FRANCIS F. c/o Mr. J. E. Longley, Lock Joint Pipe Co., Ampere, N. J. .... July 18, 1907
LOOMIS, E. L. Supt., Valparaiso Home Water Co., Valparaiso, Ind. .... July 10, 1906
LORD, CHARLES H. Supt. Water Works, Ogdensburg, N. Y. .... Aug. 10, 1918
LORD, FRANKLIN B., JR. Queens County Water Co., Cedarhurst, L. I., N. Y. .... Jan. 9, 1911
LOTT, ERSKINE H. V. P. & Gnl. Mgr., Flatbush Water Works Co., 785 Flatbush Ave., Brooklyn, N. Y. .... May 26, 1916
LOUNSBURY, WM. C. Genl. Mgr., Superior Water, Lt. and Power Co., Superior, Wis. .... May 12, 1908
LOURIE, G. E. Water Works Supt., P. O. Box 388, Bristol, Conn. .... Sept. 20, 1923
LOVEJOY, WM. H. Supt. Filtration, Louisville Water Co., Louisville, Ky. .... June 4, 1908
LOVELL, A. P. Gen. Formn., San Diego Wtr. Dept., 2516 San Marcos Ave., San Diego, Calif. .... Nov. 8, 1923
LOWTHER, BURTON. Chf. Engr. & Gen. Supt. Wtr. Wks. 1509 Cleveland Place, Denver, Colo. .... June 21, 1921
LUCAS, HUGH L. Supt., Water Pipe Extension, 404 City Hall, Chicago, Ill. .... Mar. 25, 1910
LUCE, ARTHUR T. General Mgr. Waterworks, Dept., Marshalltown, Iowa .... Apr. 10, 1919
LUCE, FRANCIS H. Supt. Woodhaven Water Supply Co., Woodhaven, N. Y. .... May 12, 1914
LUDLOW, J. L. Con. Engr., Winston-Salem, N. C. .... June 7, 1904
LUIPPOLD, G. T. c/o Wallace & Tiernan Co., 57 Post St., San Francisco, Calif. .... Feb. 16, 1924
LUNDBERG, ERIC. Water Works Supt., Galva, Ill. .... Sept. 25, 1923
LUSCOMBE, WILLIAM. Vice Prest. Gary Heat, Light and Water Co., Gary, Indiana .... May 12, 1908
LUTHY, FRED. Chf. Engr. Water Dept., Orange, N. J. .... June 8, 1921
LYKKEN, H. G. Chf. Engr., Chas. L. Pillsbury Co., 1200 2nd Ave., South, Minneapolis, Minn. .... May 27, 1922
LYNN, A. B. V.P. & Mgr., South Pittsburgh Water Co., 238 Brownsville Rd., Pittsburgh, Pa. .... Mar. 19, 1924
LYON, A. S. Supt. of Public Works, Rocky Mount, N. C. .... Dec. 8, 1923
LYON, MARTIN. Supt. Wtr. Wks., Clintonville, Wis. .... June 30, 1923
LYONS, B. F. V. Prest. and Genl. Mgr., Beloit Water, Gas and Elec. Co., Beloit, Wis. .... May 12, 1908

MCADAMS, W. A. Supt. Water & Light Dept., Farmville, N. C. .... Dec. 8, 1923
MCALARY, ALLAN. Supt. & Treasr., Camden & Rockland Water Co., Box 151, Rockland, Me. .... Apr. 18, 1922
MCALPINE, A. H. Genl. Western Agt., Hersey Mfg. Co., 211 Schultz Bldg., Columbus, Ohio .... Apr. 27, 1889
MCAMIS, JAMES W. Supt., Water Works, Greeneville, Tenn. .... Sept. 12, 1921

McBurnett, B. B. Water Superintendent, City Hall, Chickasha, Okla.	Feb. 2, 1924
McCaffrey, Wm. A. Supt. Water Works, 191 E. 6th St., Oswego, N. Y.	June 21, 1920
McCaleb, Wm. B. Gnl. Supt. Wtr. Cos. Pa. R. R., Rm. 922, Coml. Trst. Bldg., Philadelphia, Pa.	Sept. 30, 1919
McCall, Malcolm J. Gen. Engr. & Accountant, Vice-President's Office, Kansas City Power & Light Co., Kansas City, Mo.	June 28, 1924
McCarthy, William. Superintendent Water Works, Bluefield, W. Va.	May 12, 1908
McCaughern, J. C. Secretary, Bd. Fire Underwtrs. of the Pacific, 914 Merchants Exchange Bldg., San Francisco, Calif.	May 29, 1924
McClaskey, George G. Cons. Engr., 501 Renkert Bldg., Canton, O.	June 9, 1921
McClellan, Thomas D. United Piece Dye Works, Lodi, Bergen Co., N. J.	Aug. 28, 1924
McClenahan, W. T. 6218 University Ave., Chicago, Ill.	Apr. 7, 1914
McClintock, James R. 600 Walnut St., Kansas City, Mo.	Jan. 12, 1914
McConnell, Earle G. Supt. Filtration, Charlotte Water Works, Charlotte, N. C.	June 1, 1923
McCrady, MacHarvey. Chmst. and Bact., Bd of Hlth. of P. Q., 59 Notre Dame East, Montreal, Canada	Apr. 7, 1916
McCrudden, D. A. Asst. to Chief, Bur. of Wtr., 796 City Hall, Philadelphia, Pa.	July 7, 1920
McCulloh, E. Engr., Chas. L. Pillsbury Co., 1200 2nd Ave., South Minneapolis, Minn.	May 27, 1922
McDonald, Alex P. Supt., Water & Light Dept., Hibbing, Minn.	May 28, 1924
McDonald, John H. Prest. Bd. Water Comnrs., 604 Asbury Ave., St. Paul, Minn.	June 19, 1920
McDonnell, Robert E. 402 Interstate Building, Kansas City, Mo.	May 25, 1913
McElroy, Frank M. Supt. Water Dept., City Hall, Racine, Wis.	May 23, 1921
McEvoy, Edward F. 61 Winfield Ave., Jersey City, N. J.	May 28, 1924
McFarland, Charles Taylor, M.E. McFarland Engineering Co., 307 Mutual Bldg., Kansas City, Mo.	Jan. 16, 1923
McFarland, Chester R. Secty. and Genl. Mgr., Tampa Water Works Co., Tampa, Fla.	May 12, 1908
McFaul, W. L. Mgr. Water Dept. & City Engr., City Hall, Hamilton, Ont., Canada	Mar. 8, 1924
McGeehin, D. J. Supt. Wyo. Valley Water Supply Co., Markle Bank Bldg., Hazleton, Pa.	June 11, 1916
McGonigale, Wm. J. P. O. Box 2360, Louisville, Ky.	Apr. 5, 1912
McGlothlen, E. B. Supt. of Water Works, Jefferson, Iowa.	Nov. 8, 1923
McGrath, F. R. Supt., Water Works, City Hall, Chambersburg, Pa.	May 12, 1914
McInnes, F. A. Cons. Engr., 236 Bay State Road, Boston, Mass.	May 12, 1914
McIntosh, William. Gerencia, Cia Mexicana de Petro. 'El Aguila,' Apartado 150, Tampico, Tamps, Mexico.	Feb. 26, 1913
McKaughan, O. M. Supt. Water Dept., Wake Forest, N. C.	Dec. 8, 1923
McKay, John William. Boro. Engr. Mntn. Dpt. W. S. G. and E., 170 College Ave., Boro. Rchmnd., New York.	Feb. 19, 1920
McKeown, Edward. Supt. Water Works, Sherbrooke, P. Q.	June 21, 1920
McLeod, J. A. Asst. Chf. Insp., Bureau of Engineering, State Board of Health, Raleigh, N. C.	Apr. 23, 1924
McQueen, Leo E. Supt. Bd. Pub. Wks., Coldwater, Mich.	Apr. 13, 1923

McRae, John B. Cons. Engr., Jackson Building, Ottawa, Canada .... May 9, 1906
McRae, W. Percy. c/o General Supply Co., 358–360 Sparks St., Ottawa, Canada .... Jan. 30, 1924
McReynolds, B. B. Supt. Water Wks., City Hall, Colorado Springs, Col .... May 25, 1914
McRoberts, Louis H. Graduate Student, Department of Sanitary Chemistry, University of Illinois, Urbana, Ill. July 31, 1924
McWilliams, D. E. Prest., Bear Gap Wtr. Co., Mgr. Roaring Creek Wtr. Co., Box 17, Shamokin, Pa .... Mar. 16, 1922
MacDonald, Emmett. Mgr. Lincoln Water and Light Co., Lincoln, Ill .... June 7, 1904
MacDonald, W. E. City Water Works Engineer, 21 Fourth Ave., Ottawa, Canada .... May 8, 1917
MacKenzie, S. H. Engr. and Supt. Terryville and Southington Water Works, Southington, Conn .... Apr. 14, 1916
Macksey, Henry V. Supt. Public Works, 68 Pleasant St., Framingham, Mass .... May 28, 1924
Macqueen, Philip O. 1657 31st., N. W., Washington, D. C .... May 28, 1924
Maddock, R. A. Chst. & Bact., P. O. Box 214, Oshkosh, Wis. May 26, 1920
Maffitt, Dale L. Chemist, Des Moines Municipal Water Plant, Des Moines, Ia .... Apr. 2, 1918
Maffitt, M'Kean. Supt. Water & City Eng., Wilmington, N. C .... Dec. 11, 1922
Magestadt, Paul E. Desg. Engr., East Bay Water Co., 512 16th St., Oakland, Calif .... June 23, 1922
Mahlie, Winfield S. Chst. in Chge. Filtn. Plant, Fort Worth, Texas .... Feb. 28, 1923
Mahoney, Arthur Sawyer. City Engr., 94 Washington Ave. Clifton, N. J .... July 18, 1923
Mahoney, Thomas H. Supt. Water Works, 245 Broadway, Methuen, Mass .... May 28, 1924
Maillard, Albert L. 206 Walsix Bldg., 600 Walnut St., Kansas City, Mo .... Feb. 2, 1924
Main, Geo. A., M.E. Cons. Engr., 14 Baker St., Daytona, Fla .... Apr. 27, 1910
Maitland, Alexander. Cons. Engr., 1012 Baltimore Ave., Kansas City, Mo .... May 16, 1923
Majeske, Joseph F. Paymaster, Bd. Wtr. Comnrs., Detroit, Mich .... Apr. 23, 1921
Mallalieu, Willard C. Civil and Sanitary Engr., Box 43, Middlebush, N. J .... Dec. 4, 1914
Maloney, Thomas. Trustee Municipal Water Works, Council Bluffs, Ia .... June 8, 1919
Manahan, Elmer G., C.E. c/o Fuller & McClintock, Cons. Engrs., Room 1512, 170 Broadway, New York, N. Y ... June 8, 1909
Manahan, Patrick. Supt. Water Works, Briarcliff Manor, N. Y .... May 27, 1924
Mangun, L. B. Chst. in Chge. of Water Pfctn., Kansas City, Kans .... Feb. 23, 1920
Mansfield, Myron G. Div. Engr., Morris Knowles, Inc., 507 Westinghouse Bldg., Pittsburgh, Pa .... June 11, 1924
Mantel, F. A. 1043 Greenlaw Ave., Memphis, Tenn .... Mar. 5, 1924
Manville, F. D. Supt., Newport News Light and Water Co., Newport News, Va .... June 18, 1901
Mapes, John B. Constr. Engr., 38 E. Post Rd., White Plains, N. Y .... Apr. 16, 1923
Mark, Coleman B. Dist. Engr. Pa. Dpt. of Hlth., 604 N. 3rd. St., Harrisburg, Pa .... May 3, 1923

Mars, L. Donald. Asst. San. Engr., U. S. P. H. S., 76 New Montgomery, San Francisco, Cal. June 30, 1920
Marsh, Francis B. Designing Engineer, Water Supply Board of Providence, 66 Woodbury St., Providence, R. I. May 19, 1924
Marshall, Cyril E. Professional Civil Engineer, 302 Fulton Ave., Hempstead, N. Y. Aug. 12, 1924
Marshall, J. B. Chf. Engr. Tucker & Laxton, Inc., 900 Realty Bldg., Charlotte, N. C. Nov. 8, 1923
Marshall, L. A. Asst. Supt. Filtn. and Swg. Displ. Plant, Cleveland, O. May 26, 1921
Marshall, Wm. W. Box 97, Orangeville, Ontario, Canada. Apr. 5, 1923
Marston, Frank Alwyn. Cons. Engr., Metcalf & Eddy, 14 Beacon St., Boston, Mass. Feb. 20, 1922
Martin, J. C. Superintendent Water Works, Tarboro, N. C. Dec. 8, 1923
Martin, J. C. Atty. for Ohio Water Works Assn., 414 Gasco Bldg., Columbus, Ohio. May 11, 1915
Martin, J. T. Comnr. of Water, 1452 W. 98th St., Cleveland, O. Aug. 18, 1920
Martindale, R. W. 909 Monadnock Bldg., San Francisco, Calif. Nov. 8, 1923
Martinez, Conrado E. Cons. Engr., 59 Obispo St., Havana, Cuba. June 10, 1920
Marty, S. W. 331 East Doty Ave., Neenah, Wis. July 31, 1924
Marvin, George. c/oWater and Light Office, Marshfield, Wis. Sept. 3, 1924
Mason, S. J. Engr. and Supt. Water Works, Perth Amboy, N. J. May 7, 1917
Mason, Dr. W. P. Prof. Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y. May 18, 1892
Massink, A. Chst. and Bact., Central Laboratory of Holland, Utrecht, Holland. July 20, 1921
Mather, J. A., M.E. Fuller & McClintock, 879 North Parkway, Memphis, Tenn. Apr. 30, 1923
Mathis, Walter Rylander. Hemphill Station, Atlanta Station, Ga. Aug. 28, 1922
Matte, Hubert P. T. Coml. Engr., Worthington Pump and Mchy. Cpn., Harrison, N. J. July 26, 1913
Matter, L. D. 396 Winola St., Kingston, Pa. May 3, 1923
Matteson, Victor Andre. Water Works, Architect, 1402 Hartford Bldg., Chicago, Ill. May 19, 1923
Matthews, Irving E. Engr., Water Works, 43 City Hall, Rochester, N. Y. May 25, 1919
Maurice, George Holbrooke, C.E. Eagle Springs, N. C. Mar. 11, 1911
Maury, Lt. Col. Dabney H. 1445-6-7 Monadnock Block, Chicago, Ill. Aug. 22, 1894
Mauzy, Andrew B. Water Conservator, City Hall, Jersey City, N. J. Dec. 8, 1922
Mavity, J. W., C.E. 724 North F St., Wellington, Kans. May 18, 1915
Maxon, G. T. Supt. Water Board, Cortland, N. Y. June 10, 1919
Maxwell, Donald H. Prin. Asst. Engr., with Alvord, Burdick & Howson, 1417 Hartford Building, Chicago, Ill. Feb. 15, 1917
Mayo, William B. c/o Ford Motor Co., Detroit, Mich. Aug. 16, 1917
Mead, Daniel W., C.E. 120 West Gorham St., Madison, Wis. Apr. 18, 1889
Meadows, James O. San. Engr., 20 Charlevoix St., Montreal, Canada. June 21, 1920
Mears, Brainerd. Prof. of Chemistry, Williams College, Williamstown, Mass. June 24, 1915
Meeker, George R. Supt. Water Works, Geneseo, N. Y. Apr. 2, 1923
Meerburg, P. A. Central Laboratories, Sterrebosch 1, Utrecht, Holland. Feb. 16, 1924

Mees, Erich A. Consulting Engineer, Kinney Bldg., Charlotte, N. C. .... May 23, 1923
Megraw, William A. University Apartments, University Parkway, Baltimore, Md .... Apr. 24, 1921
Meinecke, M. Aktiengesellschaft, Breslau-Carlowitz, Germany .... Sept. 17, 1924
Mellen, Arthur F. Filtration Engineer, In Charge of Water Purification, Minneapolis, Minn .... Mar. 24, 1915
Mellon, T. A. Pres. Kensington Water Co., 2112 Oliver Bldg., P. O. Box 1114, Pittsburgh, Pa .... June 24, 1903
Mendell, James Herbert. Supt. Water Works, Manchester, N. H. .... June 20, 1920
Mendelsohn, Isador W. U. S. Public Health Service, 420 Call Bldg., San Francisco, Calif .... Feb. 9, 1920
Mentz, Henry A. Asst. Engr. Munic. Eng. Dept., Magnolia, Miss .... Oct. 7, 1919
Merckel, Frederick G. c/o Wallace and Tiernan Co., 180 N. Market St., Chicago, Ill .... Jan. 29, 1921
Merrill, George Field, C.E. Supt. Water Works, Ware, Mass .... Apr. 16, 1920
Merriman, Richard M. Chf. Engr. Fuller & Maitland, Engrs. K. C. Wtr. Sply., 600 Walnut St., Kansas City, Mo .... May 17, 1923
Merriman, Thaddeus. Chf. Engr. Bd. Wtr. Sup., 2224 Municipal Bldg., New York, N. Y .... May 29, 1920
Messer, Richard. Sanitary Engr., State Department of Health, 1110 Capitol St., Richmond, Va .... Sept. 27, 1911
Metcalf, John T. Asst. Engr., in Charge L. I. Watershed, 182 Lefferts Ave., Brooklyn, N. Y .... June 7, 1916
Metcalf, Leonard. Con. Civil Engr., 14 Beacon St., Boston, Mass .... June 24, 1903
Meyerherm, Charles F. Albert F. Ganz, Inc., 511 Fifth Ave., New York, N. Y .... Jan. 26, 1922
Meyers, A. H. Supt., Water Co., Columbia, Pa .... June 14, 1903
Michaels, A. P. Gen. Mgr., Orlando Utilities Comn., Orlando, Fla .... Aug. 15, 1924
Michie, John C., C.E. Supt., Water Works Dept., Durham, N. C .... June 24, 1903
Mickel, Clarence W. Chst. Muscle Shoals, Ala .... Aug. 8, 1922
Miles, H. D. Treasurer, Consolidated Water Co., Utica, N. Y .... June 30, 1924
Milholland, H. Charles. Asst. Engr. Am. W. W. & E. Co., 50 Broad St., New York, N. Y .... Apr. 20, 1923
Miller, Arthur P. 1103-16th Street, N. W., Washington, D. C .... Sept. 25, 1920
Miller, Clifford N. Hyd. Engr., 2807 Union Central Bldg., Cincinnati, Ohio .... May 13, 1915
Miller, Edwin E. Asst. Supt. Power Plants, Hackensack Water Co., Weehawken, N. J .... Mar. 11, 1914
Miller, H. E. Dctr. Bur. San. Eng., State Bd. of Hlth., Raleigh, N. C .... May 23, 1921
Miller, J. A. Supt. Water Works, 10 West Third St., Alton, Ill .... May 8, 1909
Miller, J. R. 615 So. English Ave., Springfield, Ill .... Oct. 10, 1919
Miller, Maurice L. Cons. Hyd. & San. Engr. 203 Boston, Bldg., Denver, Colorado .... Dec. 26, 1922
Miller, Melville W. Supt. Wtr. Wks. Lafayette, Ind .... May 21, 1923
Miller, Walter Edward. 1719 Madison St., Madison, Wis. Nov. 17, 1911
Miller, Warren C. City Engr., City Hall, St. Thomas, Ont. Feb. 28, 1923
Milne, Alexander. Supt. Water Works, St. Catharines, Ontario, Can .... June 24, 1903

MILO, FRED D. Supt., Welland Water Works, Welland, Ont., Canada	Mar. 8, 1924
MINOR, EDWARD EASTMAN. Gen. Mgr. New Haven Water Co., New Haven, Conn.	May 20, 1912
MINOR, L. O. Supt., Water Works, Plattsmouth, Nebr.	July 8, 1922
MITCHELL, GEORGE. City Water Engineer, Aberdeen, Scotland	July 21, 1913
MITCHELL, GEO. H. Supt. Waterworks, Revenue Dept., City Hall, Toronto, Ont.	Feb. 10, 1921
MITCHELL, JAMES J. Supt. Warren Water Co., 301 Penna. Ave., Warren, Pa.	Oct. 21, 1920
MITCHELL, NEWTON. Supt. Paris Water Co., Paris, Ky.	Jan. 7, 1924
MITCHELL, W. MONTGOMERY. Gross Ile., Mich	May 24, 1920
MOAT, CHARLES P. Chemist, Vermont State Board of Health, 2 Colchester Ave., Burlington, Vt.	Jan. 29, 1915
MOHLMAN, FLOYD W. Chf. Chst., San. Dst. of Chicago, 39th St. & Lake Michigan, Chicago, Ill.	Oct. 22, 1921
MOIR, DONALD. Auguas Corrientes, Calle Salta 1461, Rosario de Santa Fe, Argentine	June 25, 1924
MOLIS, WM. Supt. Water Works, Muscatine, Iowa	Mar. 15, 1882
MONFORT, WILSON F. Consulting Chemist, 506 N. Vandeventer Ave., St. Louis, Mo.	July 10, 1906
MONROE, H. L. Supt. Water Works, Pontiac, Mich.	July 10, 1919
MONTABONE, A. J. F. Room 2, Imperial Theater Bldg., Montreal, Canada	Nov. 9, 1922
MONTOULIEU, HENRY J., C.E. Calle B, No. 70, Entre 21 y 23, Vedado, Habana, Cuba	Nov. 17, 1911
MOORE, CHARLES E. 228 Avenham Ave., Roanoke, Va.	Oct. 5, 1923
MOORE, GEORGE S. Supt. Water Dept., Leaksville, N. C.	Apr. 23, 1924
MOORE, JOHN D. 1137 83rd St., Brooklyn, N. Y.	May 28, 1924
MOORE, L. E. Supt. Water Works, 1115 St. Claire St., Port Huron, Mich.	June 8, 1921
MOORE, R. M. Secty. and Mgr., Peoples Water Co., of Palms, Cal., 1018 Trust and Savings Bldg., Los Angeles, Cal.	June 30, 1920
MOREHOUSE, WALLACE W. Supt. Divn. of Water, 20 E. 2nd St., Dayton, O.	Jan. 16, 1923
MOREY, DAVID, JR. San. Engr., 517 Praetorian Bldg., Dallas, Texas	May 21, 1923
MORGAN, HENRY B. Grand View Drive, Peoria, Ill.	Apr. 24, 1910
MORLAN, WILBERT. Engr., 66 E. Pershing Ave., Salem, Ohio	May 24, 1922
MORRIS, CHARLES H. Supervisor of Water Works, New Brunswick, N. J.	June 7, 1916
MORRIS, J. CLYDE. Director of Water, Fairmont, W. Va.	May 28, 1924
MORRIS, SAMUEL BROOKS. Chf. Engr., Water Dept., City Hall, Pasadena, Cal.	June 10, 1920
MORROW, DAVID W., C.E. 4500 Euclid Ave., Cleveland, O.	May 8, 1922
MORSE, ROBERT B. Chf. Engr., Wash. Sub. San. Dist., Hyattsville, Md.	Mar. 11, 1915
MORTENSEN, FREDERICK C. Prof. Chemistry, Coe College, Cedar Rapids, Ia.	July 20, 1920
MOSELEY, ALEX W., M.E. Sloan Valve Co., 4300 W. Lake St., Chicago, Ill.	Oct. 11, 1923
MOSES, HOWARD E. Asst. Chf. Engr., Pennsylvania Dept. of Health, 904 N. 2nd St., Harrisburg, Pa.	Apr. 27, 1922
MOULTON, GEORGE L. Engr. c/o Tucker & Laxton, Charlotte, N. C.	Apr. 3, 1923
MOULTON, J. WENDELL. Asst. Engr., 112 E. 19th St., New York, N. Y.	Mar. 31, 1924
MOWRY, ROBERT B. c/o Wallace & Tiernan Co., Box 178, Newark, N. J.	Aug. 8, 1919

MOYER, KENNETH L. Supt., Dept. Public Service, 6th & Walnut Ave., Niagara Falls, N. Y.	Nov. 5, 1921
MUDGE, JOHN REXFORD. 246 E. Avenue 42, Los Angeles, Calif.	May 27, 1924
MUELLER, CARL. Asst. Engr. Bureau of Watei, 147 Pomona Ave., Newark, N. J.	Apr. 25, 1923
MULLERGREN, ARTHUR L. Cons. Engr., 555 Gates Bldg., Kansas City, Mo.	Oct. 21, 1919
MULLIKIN, ALFRED., C.E. Asst. Sanitary Engr., State Dept. of Health, Albany, N. Y.	Jan. 7, 1924
MUNDY, AMBROSE. Supt. Middlesex Water Co., Woodbridge, N. J.	Mar. 11, 1914
MUNN, HARVEY T. Hyd. Engr., N. B. F. U., 209 West Jackson Boulevard, Chicago, Ill.	Mar. 9, 1920
MUNRO, L. A. Brenner, Mond. & Co., Ltd., Northwich, Cheshire, England	Oct. 11, 1923
MUNROE, WALTER C. Savings Bank Bldg., Annapolis, Md.	Jan. 30, 1924
MURPHY, A. R., C.E. Fountain City, Tenn.	Apr. 7, 1911
MURPHY, FRANK J. Supt. Div. of Meters, City Hall, Milwaukee, Wis.	May 31, 1916
MURRAY, R. M. Hyd. & Structl. Engr., 326 Hutton Bldg., Spokane, Wash.	Feb. 11, 1922
MURRIN, JOHN A. Comr. Public Property, City Hall, Rock Island, Ill.	June 5, 1916
MUSER, E. FRED. Supt. Clear Springs Water Co., P. O. Bldg., Catasauqua, Pa.	Dec. 22, 1920
MUSSER, H. P. Kanawha National Bank Bldg., Charleston, West Virginia	Oct. 31, 1922
MYERS, RICHARD A. Mcpl. Engr., S. E. Undwtrs. Assn., 3 W. 10th St., Charlotte, N. C.	Dec. 12, 1921
MYERS, ROBERT HARRISON. Pub. Util. Mgr., Stratford, Ont.	Feb. 10, 1921
MYRTUE, JOHN J. Water Works Trustee, 615 S. 7th St., Council Bluffs, Iowa	Feb. 27, 1924
NAUMANN, H. T. G. 1024 8th St., Port Huron, Mich.	Apr. 3, 1923
NEBELUNG, GEORGE H. Asst. Engr., Scranton Gas & Wtr. Co., 721 Prescott Ave., Scranton, Pa.	Oct. 11, 1921
NELSON, FRED B., C.E. 906 Anderson Ave., Highbridge, New York, N. Y.	July 18, 1907
NELSON, GEORGE I. San. Engr. W. &. T. Co., 4123 Westminster Place, St. Louis, Mo.	Mar. 21, 1923
NEVILLE, WM. J. 900 Independence Bldg., Charlotte, N. C.	Aug. 31, 1923
NEVLING, J. B. Secty.-Treasr. Clearfield Water Co., Clearfield, Pa.	Oct. 16, 1914
NEWLANDS, JAMES A. San. Engr., 11 Laurel St., Hartford, Conn.	Oct. 14, 1914
NEWMAN, M. F. Mgr. Wtr. Purif. Dept. W. B. Scaife & Sons Co., Oakmont, Pa.	Aug. 29, 1923
NEWSOM, REEVES J. Water Comnr., City Hall, Lynn, Mass.	Nov. 18, 1918
NEWTON, S. D. Civil & Municipal Engr., Saluda, N. C.	June 16, 1920
NEYLON, C. M. B. Supervising Engr., State Riv. and Water Sup. Com'n, Melbourne, Australia	May 18, 1915
NICHOLS, C. S. 830 Hodge Ave., Ames, Iowa	Oct. 31, 1923
NICHOLS, E. M., C.E. 27 N. 38th St., Philadelphia, Pa.	June 16, 1919
NICHOLS, ROBERT L. Laurel Ave., Laurel, Md.	Mar. 5, 1924
NICKERSON, GEORGE SUMNER. Hyd. Engr., Forum Bldg., Sacramento, Cal.	Nov. 12, 1920
NIESLEY, W. M. 170 Broadway, Rm. 1013, New York, N. Y.	Apr. 30, 1924
NIGHSWONGER, HARRISON WORTH. Route 9, Box 22, Alva., Okla.	Aug. 22, 1919

NISHIOEDA, SATORU. City Planning Bureau, Home Dpt. of the Empire, Maru-no-Uchi, Tokio, Japan	Sept. 16, 1914
NOLAN, CORNELIUS P. Supt. Water Dept., 169 Irvington Ave., So. Orange, N. J	June 21, 1920
NOLTE, AUGUST G. Asst. Physiologist, Box 395, Ancon, C. Z.	Dec. 30, 1916
NORCOM, GEORGE D. San. Engr. Bd. of Hlth., Wilmington, N. C	June 10, 1921
NORCROSS, PAUL H. Cons. Engineer, 1404 Candler Bldg., Atlanta, Ga	Oct. 21, 1919
NORMON, EARL E. City Hall, Kalamazoo, Mich	Sept. 11, 1924
NORRIS, JOHN ALEXANDER. Chairman State Bd. of Water Engrs., Capitol Sta., Austin, Tex	June 16, 1919
NOWAKOWSKI, DR. B. State School of Hygiene, 24 Chocimska St., Warsaw, Poland	June 11, 1924
NEUBLING, EMIL L. Chf. Engr., Bureau of Water, Reading, Pa	May 29, 1895
NUSSBAUMER, NEWELL L. Asst. Engr. w/Geo. C. Diehl, 577 Ellicott Square, Buffalo, N. Y	May 29, 1895
NUTT, J. A. Supt. Water Works, Monongahela, Pa	May 17, 1916
O'CONNOR, CORNELIUS J. P. O. Box 130, Elmsford, N. Y	Mar. 19, 1924
O'CONNOR, PHILIP J. Supt. Filtn., 525 Buena Vista Ave., Warren, O	Feb. 11, 1922
OHLIGER, L. B. Supt. Water Works, Canton, O	Nov. 12, 1919
OLDING, A. I. 17 West Seventh Avenue, Redfield, South Dak	Oct. 23, 1922
OLMSTEAD, CHARLES S. Supt., The Monterey Co. Water Works, Pacific Grove, Cal	Apr. 16, 1916
OLSEN, WILLIAM C. Cons. Engr., Box 114, Raleigh, N. C	Dec. 12, 1921
O'NEALL, A. T. Supt. Water Works, Washington C. C., Ohio	Apr. 29, 1924
O'NEIL, PERRY. Contr. Engr., Municipal Engineering Co., 707 Pratorian Bldg., Dallas, Texas	Mar. 20, 1922
ORCHARD, WILLIAM J. San. Engr., Box 178, Newark, N. J	Aug. 16, 1917
O'ROURKE, JAMES. Supt. Water Works, Fulton, Ill	Nov. 14, 1915
ORR, ALEXANDER, C.E. Chief Engineer, Gloversville Water Works, Gloversville, N. Y	Aug. 7, 1909
ORR, C. A. Mgr., City Wtr. and Lt. Co., Mayfield, Ky	June 8, 1921
O'SHAUGHNESSY, M. M. City Engineer, 2732 Vallejo St., San Francisco, Cal	July 18, 1907
OUTZEN, ANDREW M. c/o Detroit City Gas Co., Detroit, Mich.	Aug. 1, 1923
OWENS, ROBERT B., B.A., B.E. Government Bdgs., Edmonton, Alberta, Canada	Apr. 27, 1914
OWINGS, NOBLE L. Asst. Engr. Washington Suburban San. Dist. Riverdale, Maryland	Jan. 4, 1923
PADDOCK, EUGENE H. Asst. Engr., N. Y. C. Bd. of Water Supply, 16 Longview Ave., White Plains, N. Y	Mar. 25, 1924
PAINTER, CARL ELLICOTT. V. P. & The D. C. Dunbar Co., Cons. Engr., 325 Walker Bank, Salt Lake City, Utah	Mar. 25, 1924
PAITOVI, ANTONIO, C.E. Rivadavia 13353, Ramos Mejia-F. C. O., Buenos Aires, A. R	July 27, 1919
PALMER, MARSHALL B. Deputy Engineer, Water Supply, Syracuse, N. Y	May 24, 1922
PARKER, C. B. Asst. Supt., Pipe System, Hackensack Water Co., Weehawken, N. J	Dec. 5, 1914
PARKER, G. H. Mgr., Kentucky Actuarial Bureau, 303 Speed Bldg., Louisville, Ky	Feb. 23, 1924
PARKER, HORATIO NEWTON. City Bact. and Chst., Main and Orange Sts., Jacksonville, Fla	June 16, 1920

PARRISH, C. A. Supt. & Mgr. City Wtr. Dept., Compton, Cal.	July 23, 1923
PARSONS, CHARLES W. Engr., Ill. Inspection Bureau, 37 S. Wabash Ave., Rm. 605, Chicago, Ill.	Apr. 2, 1923
PARSONS, CLARK D. Assoc. Engr., Filtration Divn. Bureau of Water, Porter Ave. Pumping Station, Buffalo, N. Y.	Apr. 11, 1922
PATE, R. L. Manager City Water Co., Springfield, Mo.	June 29, 1915
PATITZ, G. J. 701 Washington St., New York, N. Y.	Oct. 24, 1923
PATTERSON, T. C. Superintendent Water Works, Mt. Holly, N. C.	Dec. 8, 1923
PATTON, W. A. Pres. and Mgr. Water Co., Catlettsburg, Ky.	June 7, 1904
PATTON, W. S. Mgr. Ashland Water Works, Ashland, Ky.	May 7, 1917
PAULY, C. A. Chf. Engr. Lorain Water Works, 760 Osborne Ave., Lorain, O.	Feb. 28, 1923
PAYSON, EDGAR R. Prest. American Water Supply Co., Portland, Me.	June 27, 1905
PEARSE, LANGDON. San. Engr., The Sanitary Dist. of Chicago, S. O. Bldg., 910 S. Michigan Ave., Chicago, Ill.	Feb. 24, 1913
PEARSON, CHARLES DEARNE. Dpty. Engr. & Mgr., Wtr. Wks., Kiangse Road, Shanghai, China	Mar. 16, 1922
PEART, JOHN. Water Supply Engineer, Metropolitan W. S. and S. Board, Brisbane, Queensland, Australia	Sept. 12, 1910
PEASE, HERBERT D. Director, Pease Laboratories, Inc., 39 W. 38th St., New York, N. Y.	Feb. 6, 1924
PECK, ERMON M. Cons. Engr., 260 Edgewood St., Hartford, Conn.	July 18, 1907
PEDERSON, H. V. State San. Engr., State Bd. of Hlth., Des Moines, Ia.	Mar. 26, 1922
PEIRCE, WALTER A. Nine Springs Sewage Disp. Works, R. F. D. No. 5, Madison, Wis.	June 15, 1922
PEIRSON, A. G. Supt. Wtr. Pwr. & Lt. Comn., Weston, Ont.	Feb. 28, 1923
PENDER, L. E. Supt. Construction & Pub. Utilities, Pinehurst N. C.	Apr. 23, 1924
PEQUEGNAT, MARCEL, B.A.Sc. Supt. Kitchener Water Comm. Kitchener, Ont.	Feb. 16, 1924
PERKINS, ROGER G. Prof. Hyg. and Prvnt. Med., E. 9th St. & St. Clair Ave., Cleveland, O.	June 3, 1921
PERROW, MOSBY GARLAND. Health Officer, Lynchburg, Va.	Apr. 16, 1916
PERRY, H. W. Supt., Water Works, Box 647, Greenville, S. C.	Apr. 25, 1922
PERRY, J. ROBERT. Accountant, Municipal Water Dept., Walnut Ave. & 6th St., Niagara Falls, N. Y.	June 20, 1924
PERRY, WILLIAM. Hydraulic Engr., Maplewood Ave., Cote des Neiges, Montreal, Quebec	June 26, 1886
PETERS, WM. J. Comnr. Public Wks., 301 Court House, St. Paul, Minn.	May 23, 1923
PETERSON, LEONARD. Supt. Water Works, Power and Light Co., Crookston, Minn.	June 10, 1911
PHELPS, EARLE B. 66 Cottage Place, Ridgewood, N. J.	Oct. 19, 1914
PHILLIPS, ASA E. 26 Jackson Place, Washington, D. C.	Nov. 9, 1922
PHILLIPS, JOHN M. Harrison Engr. & Constr. Cor., Cummings, Kansas	July 22, 1920
PIATT, WILLIAM M. Cons. Engr., Durham, N. C.	Aug. 5, 1921
PIERCE, JOHN F. Bayley Terrace, So. Weymouth, Mass.	Feb. 16, 1924
PINCUS, SOL. San. Engr., 255 West 108 St., New York, N. Y.	Feb. 17, 1920
PIRNIE, MALCOLM. Consulting Engineer, 25 West 43rd St., New York, N. Y.	May 8, 1917
PITCHER, F. H. G. Mgr. and Ch. Engr., Montreal W. and P. Co., Place D'Armes Square, Montreal, Can.	June 27, 1905

Plamondon, Adrien, C.E. Engineer and Contractor, 70 St. James St., Montreal, Canada	May 22, 1916
Port, John A. Supt. Van Gilder Water Meter Co., 518 Bridgeboro St., Riverside, N. J.	May 28, 1924
Porter, D. P. Supt. Water Works, 1305 E. 4th St., Pueblo, Col.	Sept. 22, 1916
Porzelius, A. F. Supt. City Water Co., Chattanooga, Tenn.	July 7, 1920
Potteiger, Dr. C. R. 1975 Spencer St., Philadelphia, Pa.	May 26, 1920
Potter, Alexander. Consulting Engineer, 50 Church St., New York, N. Y.	July 18, 1907
Potts, Clyde. Civil and Sanitary Engr., 30 Church St., New York, N. Y.	July 10, 1906
Powell, Alexander C. Chemist, Bangor Filter Plant, Bangor, Me.	Mar. 12, 1910
Powell, Sheppard T. 4103 Hawthorne Ave., Forest Park, Baltimore, Md.	July 10, 1906
Powers, Jerome, C.E. Supt. Keokuk Water Works, Co., Keokuk, Iowa	Feb. 28, 1907
Pracy, Geo. Wesley. Supt. Spring Valley Water Co., 425 Mason St., San Francisco, Calif.	May 18, 1915
Pradas, Armando C. Engr. in Chge. Pvg. and Swge., Camaguey, Cuba	Feb. 17, 1920
Pratt, Arthur H. Chf. Engr., North Jersey Dist. Wtr. Supply Comn. 20 Clinton Street, Newark, N. J.	Jan. 4, 1923
Pratt, Gilbert H. Chemist & San. Engr., 486 Clifton Ave., Newark, N. J.	June 5, 1916
Pratt, Roger W. c/o Wallace & Tiernan Co., 201 Lloyd Bldg., Kansas City, Mo.	Feb. 13, 1924
Pray, John W. Supt. Water Works, Ft. Dodge, Ia.	June 24, 1913
Prince, George T. Cons. Engr. 629 Omaha Grain Exch. Bldg., Omaha, Nebr.	July 10, 1906
Prindle, George B. 436 W. Lexington St., Danville, Ky.	Mar. 25, 1924
Prior, J. Murray. Supt. Bureau of Water, 25 Quackenbush St., Albany, N. Y.	Apr. 10, 1924
Prochnow, Henry O. Supt. Water Works, West Allis, Wis.	June 17, 1919
Proctor, Edward M. Cons. Engr., 20 Rosemount Ave., Toronto, Ont.	May 5, 1921
Prokofieff, S. T. Hydraulic Engineer's Office, Municipal Offices, Bombay, India	Oct. 27, 1922
Provost, Andrew J., Jr. San. Expert and Hyd. Eng., 39–41 West 38th St., New York City	May 12, 1908
Pruett, G. C., C.E. Virginia, Minn.	Feb. 2, 1914
Prugh, J. I. Supt. Division of Water, City Hall, Sacramento, Calif.	Nov. 8, 1923
Pugh, Marshall R., C.E. 230 Poplar Ave., Wayne, Pa.	Apr. 8, 1905
Purcell, John L. Pres., Bd. of Water Commissioners, 124 N. Beacon St., Hartford, Conn.	June 13, 1924
Putnam, George W. State Sanitary Engineer, Jefferson City, Mo.	June 15, 1922
Quayle, LeRoy A. Chf. Mechanical Engr., Water Dept. 1440 W. 98th St., Cleveland, Ohio	June 24, 1915
Quillan, W. E. Genl. Mgr. United Gas & Elect., 16 W. Sherman, Hutchinson, Kans.	Feb. 28, 1923
Quinnell, Fred. Comnr. Public Works, Bx. 684, Roundup, Mont.	Feb. 7, 1922
Raab, Frank. Chst. & Bact. Filtn. Plant, 3940 Harriet Ave., Minneapolis, Minn.	Oct. 26, 1921
Race, Joseph. Devonshire Hospital, Buxton, England	May 18, 1914

RADCLIFFE, JOHN L. Supt. Filtn., 663 Madison Ave., Elizabeth, N. J.	Feb. 19, 1920
RADER, R. P. Supt. Lehigh Water Co., Easton, Pa.	May 12, 1908
RANDLETT, FRED MORSE. Chf. Engr., Water Bureau, City Hall, Portland, Ore.	June 16, 1920
RANDOLPH, EDWARD. P. O. Box 300, Newport News, Va.	May 24, 1922
RAPP, W. M. Supt. Const. Water Dept., P. O. Box 584, Atlanta, Ga.	May 17, 1899
RASSIER, CHRISTIAN C. Supt., Water Works, 330 W. Coal St., Shenandoah, Pa.	May 24, 1922
RATHBUN, W. S. Fire Prevention Engineer, P. O. Box 1740, Denver, Colo.	Apr. 13, 1922
RAYMOND, GEORGE B. Supt. Water Dept., Danbury, Conn.	June 16, 1919
REAGAN, JOHN F., JR. 1137 Park Ave., Utica, N. Y.	July 10, 1906
REBER, HARRY C. Pres., Angelica Water & Ice Co., 1907 Perkiomen Ave., Reading, Pa.	Aug. 20, 1924
REDFERN, W. BLAINE. Sec. Treas. James, Proctor & Redfern, Cons. Engs., 115 High Park Ave., Toronto, Ont.	Nov. 12, 1919
REED, D. A. Mgr. Water and Light Dept., Duluth, Minn.	Sept. 20, 1913
REES, S. P., C.E. 826 Lindin Ave., Hubbard Woods, Ill.	May 7, 1917
REEVES, O. LEE. Supt., Water Works Co., 26 South Jackson St., Greencastle, Ind.	May 24, 1922
REID, ROBERT H. Supt., Spring Brook Water Co., Hudson Falls, N. Y.	July 12, 1922
REID, WALTER. Supt., Water Works, Springfield, Ill.	May 24, 1922
REID, WILLIAM H. City Mgr., Bay City, Mich.	May 23, 1923
REILLY, EDWARD J. c/o Wallace & Tiernan Co., 180 N. Market St., Chicago, Ill.	Mch. 26, 1923
REINHARDT, HARRY. Asst. Chf. Engr., East Bay Water Co., Oakland, Cal.	Apr. 12, 1921
REINKE, EDWARD A. 102 C. E. Bldg., Berkeley, Calif.	Nov. 8, 1923
REISWEBER, ALEX. G. Supt. N. F. Div. Wstn. N. Y. Wtr. Co., 401 Elderfield and Hartshorn Bldg., Niagara Falls, N. Y.	Jan. 20, 1921
REQUARDT, GUSTAV J., C.E. 1828 Munsey Bldg., Baltimore, Md.	May 17, 1923
REYER, GEORGE. Supt. Water Works, Nashville, Tenn.	Apr. 16, 1884
REYNOLDS, EDWIN G., JR., C.E. New Rochelle Water Co., 514 Main St., New Rochelle, N. Y.	Feb. 26, 1921
REYNOLDS, JAMES H. Asst. Supt., Water Works, Lowell, Mass.	May 28, 1924
RHYNE, C. E. Supt. Water Works, Gastonia, N. C.	Jan. 17, 1922
RHYNUS, CLARENCE PAULDING. Bureau of Sewerage, 300 Delaware Bldg., Akron, Ohio	May 14, 1912
RICE, CLIFTON L. Genl. Del., West Palm Beach, Fla.	July 7, 1920
RICE, JOHN M. Cons. Engr., 411 Oliver Bldg., Pittsburgh, Pa.	June 8, 1921
RICE, LAWRENCE G. c/o Messrs. Fuller & McClintock, 170 Broadway, New York, N. Y.	Feb. 23, 1924
RICHARDSON, CHARLES G. Sales Mgr., c/o Builders Iron Foundry, Providence, R. I.	July 7, 1920
RICHARDSON, H. H. Engr. Wtr. Svce., Mo. Pac. R. R., 1055 Ry. Exc. Bldg., St. Louis, Mo.	Aug. 23, 1920
RIDER, JANE H. Dctr. Ariz. State Laboratory, Tucson, Ariz.	Aug. 23, 1920
RIDLEY, CLARENCE EUGENE. Bluefields, W. Va.	Dec. 5, 1918
RIFFEE, GEORGE A. Supt. Shinnston Water Board, Shinnston, W. Va.	Jan. 30, 1924
RIEBEL, THOMAS S. Supt. Queen Lane Filters, 942 E. Price St., Philadelphia, Pa.	May 28, 1924
RINGNESS, HENRY. Supt. of Accts. Peoria Water Works Co., 143-5 N. Jefferson St., Peoria, Ill.	Sept. 8, 1919

Ritchie, Edgar Gowar. Engineer of Water Supply, Metropolitan Board of Works, Melbourne, Australia....... Sept. 6, 1912
Roberts, Earl I. Asst. Engr., State Dept. of Health, 1046 The Spitzer Bldg., Toledo, Ohio....................... Jan. 11, 1918
Roberts, John S., Jr. Borough Engr., Bristol, Pa......... June 19, 1920
Roberts, William J. Cons. Engr., 616 Puget Sound Bank Bldg., Tacoma, Wash............................. Oct. 19, 1914
Robinson, Brice J. Pres.-Mgr. Atascadero Mutual Water Co., Atascadero, Cal................................ May 20, 1920
Robinson, Leonard C. Supt. Water and Sewer Dept., Concord, Mass....................................... July 18, 1907
Robinson, W. W. Supt. & C.E., Russell Manufacturing Co., Alexander City, Ala................................ Mar. 31, 1924
Robinson, William P. 1700 East 3rd Ave., Denver, Colo... June 8, 1897
Rodgers, C. M. Asst. Superintendent, Salisbury Water Works, Salisbury, N. C.............................. Dec. 8, 1923
Rodman, George Edward. Asst. Engr. Dept. W. S. G. and E., 2449 Municipal Bldg., New York, N. Y................ Jan. 24, 1919
Roen, O. S. City Service Manager, City Hall, Ontario, Calif. Oct. 18, 1923
Rohrbach, Wm. R. Mgr. Sunbury Water Co., Sunbury, Pa. July 10, 1906
Rollins, Frank L. Supt., Water & Sewage Purification, 500 North 8th St., Cambridge, Ohio...................... Apr. 18, 1922
Romig, C. O. Secty. and Supt. Water Supply Co., Dennison, O.. Oct. 23, 1917
Roos, Charles M. Secty. and Supt. Cairo Water Co., Cairo, Ill.. May 18, 1913
Roper, Roswell M. Engr., Bd. of Water Comnrs., East Orange, N. J.. May 10, 1919
Rosenthal, Helman. 2906 Peabody Ave., Dallas, Texas.... June 3, 1918
Rosentreter, Herman. Engr. of Water Supply, City Hall, Newark, N. J.. Mar. 12, 1908
Roskelley, C. O. Civil Engineer, Brigham City, Utah....... Feb. 20, 1924
Ross, R. A. Cons. Engr., 288 St. James St., Montreal, Canada. May 15, 1914
Rossiter, Edgar A., C.E. Burnham Bldg., Suite 1729, 160 W. Randolph St., Chicago, Ill........................... Oct. 14, 1918
Rouse, B. P. Mgr., Western Div. Appalach Power Co., P. O. Box 24, Welch, W. Va............................ Jan. 30, 1924
Routh, James W. Bureau of Municipal Research, Athletic Club Building, St. Paul, Minn. .... June 4, 1920
Routledge, George Graham. Supt. Water Distb. Section, 332 St. Clair Ave., E., Toronto, Int.................. Mar. 18, 1919
Rowe, E. A. 1104 Central Building, Los Angeles, Calif..... Nov. 9, 1922
Rowe, E. J. Supt. Water and Light Dept., Wellsville, N. Y... June 3, 1921
Rudd, William C. P. O. Box 380, Cincinnati, Ohio......... July 14, 1923
Rudderow, Maurice B. Mgr. Merchantville Water Co., Merchantville N. J.................................. June 23, 1914
Rue, J. A. Water Engr., Cent. Ill. Pub. Service Co., 1217 Marshall Ave., Mattoon, Ill.......................... Apr. 7, 1916
Ruggles, A. V. 1375 E. 111th St., Cleveland, Ohio.......... Aug. 16, 1920
Rupp, Daniel H. Water Department, East Liverpool, Ohio.. Oct. 14, 1922
Russell, Bernard John. 346 West Grand Boulevard, Detroit, Mich.. Jan. 30, 1924
Russell, Brinton. Supt. Water Co., Norristown, Pa...... May 23, 1923
Russell, D. A. Chief Chemist, Youngstown Sheet & Tube Co., Youngstown, Ohio.............................. May 31, 1924
Russell, Norman F. S. 1421 Chestnut St., Philadelphia, Pa.. Dec. 10, 1915
Rust, C. H. Toronto Electric Lt. Co., 12 Adelaide St., Toronto, Ont.. June 24, 1903

RUTH, EDWARD D. Supt., Water Dept., City Hall, Lancaster, Pa. .... May 1, 1922
RYLE, JOHN. Asst. Engr. Passaic Water Co., 158 Ellison St., Paterson, N. J. .... Dec. 3, 1919

SACKETT, ROBERT L. Dean, School of Engineering, Pa. State College, State College, Pa. .... Nov. 21, 1912
SAFFORD, ARTHUR T. Engr., Proprietors Locks and Canals, 66 Broadway, Lowell, Mass. .... Feb. 4, 1921
SALCINEZ, J. L., C.E. Pedro A. Perez No. 19, Guantanomo, Cuba. .... Oct. 31, 1923
SALISBURY, J. W. Civil Engineer, Chinchilla Lackawanna Co., Penna. .... June 13, 1924
SALMOND, JAMES J. Manager *Canadian Engineer*, 62 Church St., Toronto, Ont. .... July 18, 1907
SANBORN, JAMES F. 30 Church St., Rm. 414, New York, N. Y. Aug. 22, 1921
SANDERSON, A. U. Supt. Toronto Filtn. Plant, Foot of John St., Toronto, Canada. .... June 9, 1920
SANDO, WILL J. Consulting Engineer, 1013-16 Wells Building, Milwaukee, Wis. .... June 27, 1905
SANZENBACHER, GEORGE. Engr. and Supt. Dept. of Water, Newark, N. J. .... June 27, 1905
SAUNDERS, WM. E., E.M. Librarian, United Gas Improvement Co., Broad and Arch Sts., Philadelphia, Pa. .... July 26, 1919
SAVAGE, W. B. Supt. Water Works, Knoxville, Iowa. .... Jan. 8, 1921
SAVILLE, CALEB MILLS. Mgr. and Chf. Engr. Water Works, 53 North Beacon St., Hartford, Conn. .... Mar. 18, 1916
SAVILLE, THORNDIKE. Assoc. Prof. Hyd. and San. Eng., Univ. of N. C., Chapel Hill, N. C. .... Aug. 30, 1920
SAWAI, JUNICHI. Chf. Engr. Water Works, Osaka, Japan... July 21, 1919
SAWIN, LUTHER R. Bacteriologist in Charge of Mt. Kisco Laboratory, Mt. Kisco, N. Y. .... July 14, 1916
SAYER, FRED D. Borough Engr. and Supt. of Water, Brookville, Jefferson Co., Pa. .... Apr. 22, 1914
SCACCIAFERRO, S. JOHN. Civil and Sanitary Engr., 506 Highland Ave., Clifton, N. J. .... Aug. 26, 1921
SCARTH, STANILAND. Supt. Water, Sewer and Light, Newark, N. Y. .... Aug. 9, 1916
SCHAUT, GEORGE G. 925 W. Susquehanna Avenue, Philadelphia, Pa. .... Oct. 23, 1922
SCHEFFER, LOUIS K. Engineering Asst., San Engr., 1013 Green St., Harrisburg, Pa. .... Jan. 26, 1924
SCHERER, FREDERICK G. Asst. Engr. Bureau of Water, City Hall, Newark, N. J. .... Dec. 26, 1919
SCHIEDEL, C. W. Secy-Treas. and Genl. Mgr. Water and Light Com'n., Waterloo, Ont. .... Apr. 26, 1921
SCHIMMEL, L. H. Pontiac Water Works, Wesson St., Pontiac, Mich. .... May 23, 1923
SCHNABEL, WILLIAM R., C.E. Asst. Supt. Bureau of Water, 242 S. Madison St., Allentown, Pa. .... Apr. 10, 1924
SCHOLZ, ROBERT O. Senior Engr. Division of Water, 45 Seymour Ave., Newark, N. J. .... Feb. 19, 1916
SCHOONMAKER, GEORGE NELSON. Asst. Comnr. Dvn. of Water, 716 Stickney Ave., Toledo, Ohio. .... Aug. 22, 1921
SCHROEDER, E. C. Manager, Water Works Plant, 617 No. 10th St., Manitowoc, Wis. .... Aug. 26, 1924
SCHWABE, WALTER P. Prest and Mgr. The Thompsonville Water Co., 15 Central St., Thompsonville, Conn. .... Nov. 3, 1914
SCHWADA, JOSEPH P. City Engineer, 923 49th St., Milwaukee, Wis. .... May 28, 1924

SCHWARTZ, FREDERICK W. 439 Hamilton St., Albany, N. Y.	July 18, 1907
SCOFIELD, C. L. Canadian Fire Und. Assn., 524 Coristine Bldg., Montreal, Can.	Apr. 22, 1920
SCOTT, J. SHELDON. Chst. in Chge. Pfctn. Plant., 1623 State St., Steubenville, O.	Nov. 27, 1920
SCOTT, ROSSITER, S., M. E. With Nicholas S. Hill, Jr., 112 E. 19th St., New York, N. Y.	Mar. 4, 1922
SCOTT, WALTER M. Chrmn. Greater Winnipeg Wtr. Dist., New Civic Offices, Winnipeg, Manitoba.	Mar. 11, 1914
SCOTT, WARREN J. Asst. Engr., State Dept. of Health, 8 Washington St., Hartford, Conn.	Oct. 14, 1922
SEDGWICK, C. E. Distr. Mgr., Pacific Gas and Elec. Co., Dixon, Calif.	Mar. 5, 1924
SEERY, FRANCIS J. Prof. Hyd. Eng., Cornell Univ., 504 University Ave., Ithaca, N. Y.	Nov. 3, 1919
SEIBERT, JOSEPH. Supt. Water Works, St. Cloud, Minn.	June 5, 1912
SELIGMAN, FELIX. Pump Station, Duluth, W. & L. Dept., Lakewood, Minn.	June 11, 1924
SENIOR, SAMUEL PALMER. Pres. and Engr. Bridgeport Hyd. Co., Bridgeport, Conn.	July 10, 1906
SHARON, JOHN J. Asst. to Mgr. S. V. Wtr. Co., 375 Sutter St., San Francisco, Cal.	Feb. 10, 1920
SHAW, A. W. Engineer, Box 1516, Brandon, Manitoba, Can.	Jan. 17, 1911
SHAW, C. M. Supt., Water Works, P. O. Box 822, Prescott, Arizona	Apr. 18, 1922
SHAW, HARRY B. Asst. Engr., Washington Subn. San. Dist., Hyattsville, Md.	Apr. 2, 1923
SHAW, WALTER A. State Public Utilities, 1509 Farwell Ave., Chicago, Ill.	July 10, 1906
SHEAL, ROBERT E. Cons. Engr., B. F. Keith Bldg., Cleveland, Ohio	June 13, 1921
SHELDON, HOWARD W. Water Works Engr., 120 S. Cedar St., Lansing, Mich.	Apr. 5, 1922
SHELL, R. G. Supt. Filtration Plant, R. F. D. No. 4, Fayetteville, N. C.	June 11, 1924
SHEPARD, E. R. Consulting Electrical Eng., 231 So. Clark St., Rm. 1726, Chicago, Ill.	May 3, 1922
SHEPARD, GEORGE M. Chf. Engr. Dept. Public Works, City Hall, St. Paul, Minn.	Nov. 12, 1920
SHERMAN, ARTHUR L. 20 Clinton St., Newark, N. J.	Feb. 16, 1924
SHERMAN, CHARLES W. Cons. Engr., 14 Beacon St., Boston, Mass.	May 14, 1914
SHERMAN, HAROLD, C.E. 50 Vincent Pl., Lynbrook, N. Y.	Mar. 5, 1924
SHERMAN, LEROY K. President, Randolph-Perkins Company, First National Bank Bldg., Chicago, Ill.	Sept. 10, 1924
SHERMAN, WALTER J., C.E. The W. J. Sherman Co., Toledo, Ohio	May 12, 1908
SHERRERD, MORRIS R. Cons. Engr., Dept. Street and Public Improvts., City Hall, Newark, N. J.	June 7, 1897
SHIBLEY, E. H. Supt. Port Costa Water Works, 433 California St., San Francisco, Cal.	June 2, 1920
SHIBLEY, KENNETH. Civil and Hydraulic Engr., 1218 Merchants Exchange, San Francisco, Cal.	Sept. 1, 1915
SHIELDS, W. S. 1201 Hartford Bldg., Chicago, Ill.	May 17, 1899
SHIPMAN, EUGENE H. Prest. Clear Springs Wtr. Co., 624 North Main St., Bethlehem, Pa.	July 14, 1920
SHOEMAKER, G. E. Genl. Mgr., Water Works, Waterloo, Iowa,	June 5, 1911
SIDDONS, JOSEPH S. V. Supt. Torresdale Filters, 1648 Dyre St., Philadelphia, Pa.	Feb. 28, 1916

Siedle, Adolph G. Asst. Engr., Water Dept., 480 East 124th St., Cleveland, O. .... June 13, 1921
Siems, V. Bernard. Water Engineer, Water Dept., City Hall, Baltimore, Md. .... May 11, 1916
Simms, R. B. Supt. Water Works, Spartanburg, S. C. .... May 24, 1922
Simonds, Fred W. 4 Addison Place, Ridgewood, N. J. .... May 13, 1918
Simons, George W., Jr. San. Engr., 364 Avondale Ave., Jacksonville, Fla. .... July 23, 1920
Simpson, J. H. 238 Brownsville Road, Mt. Oliver Station, Pittsburgh, Pa. .... Sept. 11, 1924
Skinker, Thomas Julian. Engr. in Charge of Distribution, 312 City Hall, St. Louis, Mo. .... July 31, 1924
Skinner, Alfred E. Western Mgr. Pitometer Co., 53 W. Jackson Blvd., Chicago, Ill. .... Mar. 14, 1921
Slater, E. O. Chemical Engr., 245 So. Los Angeles St., Los Angeles, Calif. .... Apr. 11, 1922
Slaughter, J. M. Supt., Water Works, Meridian, Miss. .... May 28, 1924
Sleeper, Wm. H. Constr. Engr. Fuller & McClintock, 319 Summit Cherry Bldg., Toledo, Ohio .... May 16, 1923
Slingerland, Wm. H. Box 142, Slingerlands, N. Y. .... Apr. 30, 1924
Smalley, James D. Supt. Water Dept., 1027 B St., Hayward, Ala. Co., Calif. .... Aug. 29, 1923
Smalshaf, A. J. Columbus Water Works, Columbus, Ga. .... Dec. 26, 1916
Smedberg, C. W. Water Dept., Greensboro, N. C. .... Dec. 11, 1922
Smith, Arthur H. 100 Beechwood Ave., Bound Brook, N. J. .... May 8, 1918
Smith, E. H. 615 Station Ave., Haddon Heights, N. J. .... Apr. 20, 1924
Smith, Elroy G. Cons. Engr., 313 Herald Bldg., Augusta, Ga. June 16, 1920
Smith, J. Waldo. Consulting Engr., Board of Water Supply, Municipal Building, New York, N. Y. .... June 15, 1898
Smith, John D. Supt., Water Works, P. O. Box 366, Cheraw, S. C. .... Apr. 29, 1924
Smith, L. B. Mgr. Westmoreland Water Co., Greensburg, Pa. .... July 26, 1915
Smith, Leon A. Supt. Water Works, City Hall, Madison, Wis. .... May 17, 1916
Smith, Merritt Haviland. Chf. Engr., Bureau of Water Supply, Municipal Building, New York, N. Y. .... July 15, 1915
Smith, Milton Perry. Supt., Parks & Public Property, Sioux City, Iowa .... Apr. 23, 1924
Smith, R. J. Mgr., Scty-Trs. Perth Hydro-Electric System, Perth, Ont. .... June 10, 1911
Smithrim, E. R. Secty-Treas. Pub. Util. Comn., Box 55, Strathroy, Ont. .... Apr. 3, 1919
Snell, George H. 49 County St., Attleboro, Mass. .... July 7, 1906
Snell, T. W. Genl. Supt. Coast Valleys G. & E. Co., Salinas, Calif. .... Mar. 21, 1923
Snyder, Frederic Antes. 105 Carnegie Ave., East Orange, N. J. .... Mar. 13, 1920
Snyder, S. B. Supt. Wtr. Wks., 105 S. Madison St., Stoughton, Wis. .... July 16, 1923
Soost, C. W. Supt. Water Works, Mobile, Ala. .... Oct. 27, 1922
Sosnowski, John B. Prest. Bd. Wtr. Cmnrs., 1093 E. Grand Boulevard, Detroit, Mich. .... May 29, 1920
Spaulding, Charles H. Filt. Engr., Okla. City Water Dept., Oklahoma City, Okla. .... July 29, 1924
Spear, Walter E. Merrick, N. Y. .... Jan. 8, 1915
Speller, Frank Newman. Metallurgical Engr., 1802 Frick Bldg., Pittsburgh, Pa. .... June 10, 1920
Spencer, C. A. Supt. Mountain Wtr. Sply. Co., 208 Couler Bldg., Greensburg, Pa. .... Oct. 10, 1919

Spencer, H. M. Director of Research, Seydel Chemical Co. Jersey City, N. J.	Jan. 16, 1924
Spencer, Percy S. Eng. Asst., Aberdeen Wtr. Wks., 39 Brimmond Place, Torry, Aberdeen, Scotland	May 3, 1922
Sperry, Walter A. Chemist, Filtration Plant, Grand Rapids, Mich.	Dec. 5, 1914
Spiller, H. C. Prest. Jackson Mutual Water Co., 17 Water St., Boston, Mass.	July 2, 1918
Spire, Leonard S. Chf. Pitometer Operator, Bureau of Water, 50 Lake View Ave., Buffalo, N. Y.	July 5, 1918
Squires, Anson W. Supt., Tampa Water Works Dept., P. O. Box 461, Tampa, Fla.	Mar. 8, 1924
Stainton, H. Waterworks Inspector, Western Canada Fire Underwriters Assn., 1100 Paris Bldg., Winnipeg, Man.	June 26, 1916
Stanfield, C. E. Pana, Ill.	Dec. 24, 1914
Stanley, William E. c/o Pearse, Greeley & Hansen, 6 No. Michigan Ave., Rm. 1710, Chicago, Ill.	Nov. 9, 1922
Starbird, Harold R. Sodus, N. Y.	June 13, 1921
Stark, Burr M., C.E. Lake Ave., Troy, N. Y.	Dec. 26, 1919
Starr, Roland H., B.A.Sc. Engr. Wtr. Lt. and Pwr. Wks., Box 694, Orillia, Ont.	Jan. 16, 1920
Stearns, Harrington P. c/o Queens Co. Water Co., Far Rockaway, N. Y.	Jan. 22, 1914
Stearns, Ralph H. c/o Messrs. Sanderson Porter, 52 Willam St., New York, N. Y.	May 31, 1924
Stein, Milton F. San. Engr., 6753 Lafayette Ave., Chicago, Ill.	June 16, 1919
Stephen, Eng. Lt. Cmdr. Charles, R.N. Supt. Engr., Macdonald College, P. Q., Canada	Apr. 21, 1916
Stephenson, Frank H. Asst. Supt. Water Supply, 5171 Webb Ave., Detroit, Mich.	May 24, 1920
Sterosky, Joseph. Supt. Water Dept., 909 Oak St., Port Huron, Mich.	May 28, 1924
Stevens, Harold C. Consulting Engineer, 150 Nassau St., New York, N. Y.	May 9, 1914
Stevens, Harry. Cons. Engr., Union Trust Building, Washington, D. C.	May 12, 1916
Stevenson, W. L. Chf. Engr., Pa. Dpt. of Hlth., P. O. Box 622, Harrisburg, Pa.	May 1, 1922
Stewart, Frederick G. Pres., Waterloo Water Co., Waterloo, N. Y.	May 28, 1924
Stewart, Fred J. Mgr. The Merton G. Hall Co., Centerville, Ia.	Apr. 12, 1920
Stewart, Spencer W. Prest. Ambursen Constr. Co. Inc., Grand Central Terminal Bldg., New York, N. Y.	Feb. 4, 1921
Stoldt, G. F. Hillview, Ill.	Dec. 16, 1922
Stone, E. W. Analyst, Pueblo Water Works, P. O. Box 818, Pueblo, Col.	July 22, 1916
Stone, Ormond O. 1112 Hollingsworth Bldg., Los Angeles, Calif.	Jan. 2, 1924
Stone, R. D. Prest. and Mgr., 400 Chestnut St., Philadelphia, Pa.	Dec. 16, 1915
Storrie, William, C.E. Room 625, Confederation Life Bldg., Toronto, Ont.	Mar. 11, 1915
Storrs, John W., C.E. Mbr. N. H. Pub. Serv. Comn., Concord, N. H.	Oct. 7, 1919
Story, Stephen Bond. Director Bur. Mun. Research, 25 Exchange St., Rochester, N. Y.	Mar. 30, 1920
Stover, Frederick H. Crescent Hill Filters, Louisville, Ky.	June 3, 1912

STRANG, JOHN A., C.E. Wallace & Tiernan Co., 201 Lloyd Bldg., 9th & McGee Sts., Kansas City, Mo.	Feb. 8, 1923
STRATTON, C. C. c/o J. C. Michie, Supt. Water Wks., Durham, N. C.	Dec. 8, 1923
STRATTON, THOMAS F. Water Comnr., Memphis, Tenn.	May 21, 1923
STREANDER, PHILIP B. 5919 Carpenter St., Apt. B, Philadelphia, Pa.	Dec. 8, 1923
STREETER, H. W. San. Engr., U. S. Pub. Hlth. Serv., Third & Kilgour Sts., Cincinnati, Ohio	Apr. 16, 1915
STREITHOF, CHAS. Gen. Supt. Water Dept., 524 Cleveland Ave., Evansville, Ind.	May 23, 1923
STRINGFELLOW, HENRY A. c/o Parrish & Co., Apartado 6, Barranquilla, Colombia, S. A.	July 25, 1924
STROHMEYER, JOSEPH S. Asst. Civil Engr. Water Dept., 5007 Wilson Ave., Baltimore, Md.	May 11, 1922
STROMQUIST, W. G. City Health Dept., Room 2, Court House, Memphis, Tenn.	Nov. 17, 1914
STROUSE, PAUL EWING. City Engineer, Rocky Ford, Col.	Aug. 31, 1923
STRUTHERS, D. L. City Manager, Gastonia, N. C.	Dec. 8, 1923
SUGGS, JOHN H. c/o Durham Water Works, Durham, N. C.	Apr. 4, 1924
SUITOR, ROY B. Supt. Public Service, Walnut Ave. & 6th St., Niagara Falls, N. Y.	June 20, 1924
SULLIVAN, C. J. Supt. Water Works, 319 Second Ave. North, Chisholm, Minn.	June 23, 1913
SULLIVAN, EDMUND C. U. S. Public Health Service, 370 Seventh Ave., Room 1551, New York, N. Y.	Apr. 14, 1924
SULLIVAN, PAUL K. Supt., Water Plant, Box 212, Cramerton, N. C.	July 28, 1924
SURVEYER, ARTHUR. Cons. Engr., 511 St. Catherine St., W., Montreal, Canada	Apr. 18, 1916
SUTER, RUSSELL. Sr. Asst. Engr., Cons. Comn., Albany, N. Y.	Oct. 9, 1914
SUTHERLAND, IAN M., M.C.E. Engng. Drftsmn. M. M. B.W., 110 Spencer St., Melbourne, Australia	June 16, 1920
SUTTLE, CLIFFORD B., C.E. Asst. Treas. Tampa Water Works Co., 401 Chestnut St., Philadelphia, Pa.	June 10, 1919
SWAAB, S. M. Cons. Engr., City Hall, Room 210, Philadelphia Pa.	Mar. 19, 1924
SWANSON, MELVIN O. Supt. Wtr. & Lt. Dept., City Bldg., Jamestown, N.Y.	Aug. 9, 1922
SWARD, FRANCIS L. Comnr. of Water, 840 Penobscot Bldg., Detroit, Mich.	June 13, 1921
SWEARINGEN, C. V. State Water Survey, Urbana, Ill.	Jan. 2, 1924
SWEENEY, J. H. Chief Engr. Water Works, Wilmington, N. C.	Dec. 8, 1923
SWEET, E. O., C.E. Birmingham Water Works Co., 1106½ Virginia Ave., Birmingham, Ala.	May 19, 1916
SWITZER, JOHN A. Cons. Engr., Prof. Hydraulic and Sanitary Eng., University of Tenn., Knoxville Tenn.	May 10, 1915
SYMONDS, HENRY A. Cons. Hyd. Engr., 75 Crofton Road, Waban, Mass.	Feb. 26, 1921
SYMONS, M. M. Chief Engr., Interstate Water Co., 1009 West Fairfield St., Danville, Ill.	Feb. 8, 1915
TABER, GEORGE A. Consulting Engineer, Beacon Bldg., 6 Beacon St., Boston, Mass.	June 3, 1912
TAINTER, F. S. 84 Pine St., New York, N. Y.	Oct. 4, 1919
TAKAYAMA, O. Director, Morita Mfg. Co., Kyuaemon-Cho 1-Chome, Minami-ku, Osaka, Japan	Mar. 14, 1924
TALBOT, ARTHUR N. Prof. Municipal and Sanitary Engr., University of Illinois, Urbana, Ill.	Aug. 22, 1894

Talbot, Earle. Secty. Treasr. and Genl. Asst. Supt., Hackensack Water Co., Box F., Weehawken, N. J....	May 1, 1920
Talbott, Frank. Supt. Sec. and Treas. Water Works, Danville, Va.	June 7, 1904
Tanner, Fred W., Ph.D. Bact. Dept., 361 Chem. Bldg., University of Illinois, Urbana, Ill.	Nov. 3, 1914
Tanner, I. B. Supt. Wtr. Svce. Dpt., Jos. E. Nelson and Sons, 3240 S. Michigan Ave., Chicago, Ill.	Sept. 5, 1919
Tarbett, Ralph E. San. Engr., U. S. P. H. Svce., 321 Mills Bldg., El Paso, Texas.	July 5, 1921
Tay, Samuel Wright. San. Engr., Ttl. Bd. of Hlth., Hawaii, 2413 Lower Manoa Road, Honolulu, T. H.	July 14, 1920
Taylor, Arthur. Cons. Engineer, 626 So. Spring St., Los Angeles, Calif.	July 31, 1924
Taylor, Geo. R. San. Chmst., 115 Wyoming Ave., Scranton, Pa.	May 11, 1908
Taylor, Samuel A. Con. & Constructing Engr., 7th Floor, 1st Natl. Bank Bldg., Pittsburgh, Pa.	June 10, 1902
Taylor, Stephen H. Supt. Water Works, 312 Municipal Bldg., New Bedford, Mass.	June 3, 1919
Taylor, W. E. Chf. Engr., Water Co., Water St. and Big 4, Terre Haute, Ind.	July 18, 1903
Ternes, Albert P. Water Commissioner, 7435 La Salle St., Detroit, Mich.	May 15, 1922
Thom, L. G. City Manager, 317 55th St., Newport, News, Va.	May 23, 1923
Thomas, A. H. R. Supt. Waterworks, Box 227, New Toronto, Ont.	Feb. 28, 1923
Thomas, Charles F. 5915 Springfield Ave., Philadelphia, Pa.	Aug. 29, 1923
Thomas, E. E. Point Pleasant, W. Va.	Mar. 31, 1924
Thomas, E. J. Cons. Engr., Box 613, Minot, N. Dak.	Dec. 11, 1922
Thomas, Robert J. 85 Eleventh St., Lowell, Mass.	May 16, 1900
Thompson, Alvin B. Supt. Kennebec Water Dist., Waterville, Me.	June 26, 1919
Thompson, David G. Associate Geologist, U. S. Geological Survey, Dept. of Conservation & Development, State House, Trenton, N. J.	
Thompson, Rudolph E. Asst. Chst. Filt. Plant, 596 Milverton Blvd., Toronto, Ont.	Mar. 16, 1922
Thorndike, Sturgis H. Cons. Engr., 200 Devonshire St., Boston, 9, Mass.	Feb. 26, 1921
Tighe, James L. Cons. Engr., 189 High St., Holyoke, Mass.	Apr. 17, 1889
Tilden, James A. V. Pres. and Genl. Mgr. Hersey Mfg. Co., South Boston, Mass.	Apr. 19, 1889
Tisdale, Ellis S. Director, San. Eng. Division, State Dept. of Health, Charleston, W. Va.	Aug. 26, 1916
Todd, William. Supt. Elec. Light and Water Works, Austin, Minn.	June 18, 1901
Toensfeldt, Kurt. Asst. Chief Mechanical Engr., Water Department, 308 City Hall, St. Louis, Mo.	June 13, 1922
Toler, W. C. Supt. Filtration Water Dept., 211 North Virginia St., Goldsboro, N. C.	Dec. 8, 1923
Tolles, Frank C., C.E. 1120 Second National Bldg., Akron, Ohio.	Aug. 1, 1923
Tolson, Albert. Supt. of Filters, 206 Rochelle Ave., Philadelphia, Pa.	Jan. 29, 1916
Tomlinson, Sam. 100 Robinson Road, Singapore, S. S.	July 14, 1887
Toms, R. C. Mgr. Marion Water Co., Marion, Iowa.	Apr. 4, 1924
Totten, Robert L. Cons. Engr., 415 Brown Marx Bldg., Birmingham, Ala.	Mar. 26, 1923

TOWLE, ELTON L. Hyd. & Mech. Engr., 402 East 37th St., Paterson, N. J.	Apr. 5, 1922
TOWNLEY, DAVID H. Engr., Elizabethtown Water Co., 139 Murray St., Elizabeth, N. J.	May 26, 1916
TOYNE, J. W. Engineer, South Bend, Ind.	July 10, 1906
TRACE, V. E. Supt. Water Works Dept., City Hall, Santa Barbara, Cal.	July 23, 1920
TRAFFORD, E. W. Dctr. Pub. Util., 109 City Hall, Richmond, Va.	May 8, 1922
TRAUTWINE, JOHN C., JR. Civil Engr., 257 S. Fourth St., Philadelphia, Pa.	May 27, 1896
TRAVIS, F. M. Prest., The Torrington Water Co., P. O. Box 76, Torrington, Conn.	July 20, 1917
TRAX, E. C. Chemist, Filtration Plant, McKeesport, Pa.	June 9, 1911
TREMBLAY, J. A., C.E. Engr., Water & Sewerage Dept., 98 Bougainville Ave., Quebec, Canada	May 28, 1924
TRIBUS, LOUIS LINCOLN, C.E. 15 Park Row, New York City.	May 12, 1906
TRIMBLE, EARLE J. Supervising Engineer, Water Dept., 85 Otsego St., Ilion, N. Y.	May 15, 1924
TROBRIDGE, CHARLES E. San. Engr., American Water Works & Elect. Co., 355 Warburton Ave., Yonkers, N. Y.	Apr. 18, 1922
TROGDON, J. S., C.E. Leaksville, N. C.	Dec. 11, 1922
TRUE, ALBERT O. Sanitary Engr., Proximity Mfg. Co., Denim Branch, Greensboro, N. C.	Aug. 28, 1922
TRUMBORE, FRANK J. Master Mechanic, 743 N. Main St., Pleasantville, N. J.	Apr. 7, 1922
TURNER, J. W. Superintendent, Waterworks, Edmonton, Alberta, Canada	June 6, 1922
TURNER, P. G. Route 3, Wilson, N. C.	Dec. 8, 1923
TUTTLE, ARTHUR S. Chf. Engr., Bd. of Estimate and Apportionment, Municipal Building, New York, N. Y.	July 10, 1916
TYGERT, CYRIL B. 165 Home Avenue, Rutherford, N. J.	Nov. 14, 1922
TYLER, D. M. Supt. Elkins Water Works, 153 River St., Elkins, W. Va.	Feb. 20, 1924
TYLER, ORVILLE Z. Supt. Water and Power, Main and Orange Sts., Jacksonville, Fla.	May 4, 1921
UELTZEN, EDWARD JOHN. Supt. Wtr. & Lt. Dpts., Rollo, Mo.	May 7, 1923
ULRICH, BERNARD L. Supt., Water Works, Manhattan, Kans.	Feb. 20, 1922
UPTON, THOMAS HAYNES. Lecturer, Engineering School, University of Melbourne, Victoria, Australia	Aug. 24, 1923
VAIL, CHARLES D. Mgr. Improvements & Parks, City Hall, Denver, Col.	Jan. 8, 1921
VAIL, R. M. Asst. Supt., Spring Brook Water Supply Co., 30 N. Franklin St., Wilkes Barre, Pa.	Nov. 27, 1923
VALENTINO, JOHN G. Supt. Water Dept., Savannah, Ga.	Apr. 30, 1923
VANARNUM, WILLIAM I. Supt. Filtration, 925 High St., Youngstown, O.	Feb. 7, 1922
VAN BENSCHOTEN, JAY. Mech. & W. W. Engr., 73 Adelaide St. East, Toronto, Ont.	June 10, 1923
VANBRUNT, W. D. Prest. Water Works Co., Southampton, N. Y.	Aug. 23, 1920
VAN GILDER, L. Engr. and Supt. Water Dept., City Hall, Atlantic City, N. J.	July 10, 1906
VANGORDER, J. R., C.E. 408 Salt Springs Road, Syracuse, N. Y.	Mar. 20, 1922
VANKEUREN, C. A. Chief Engr., Wat. Dept., City Hall, Jersey City, N. J.	May 23, 1923

Van Loan, Seth M. Deputy Chief Bureau of Water, 709 City Hall, Philadelphia, Pa.	May 12, 1914
Van Trump, S. N. Chf. Engr. and Supt. Water Wks., Wilmington, Del.	Feb. 7, 1916
Vauquette, Joseph Henri. City Manager, Shawinigan Falls, Can.	Dec. 15, 1923
Veatch, N. T., Jr. Cons. Engr., 701–5 Mutual Building, Kansas City, Mo.	Dec. 16, 1915
Vermeule, Cornelius C., C.E. 38 Park Row, New York, N. Y.	June 8, 1909
Vertefeuille, Joseph A. Asst. Engr. Dpt. W. S. G. and E. of N. Y., 50 Court St., Brooklyn, N. Y.	May 16, 1916
Vest, W. E. Supt. Water Works, Charlotte, N. C.	May 3, 1911
Villermin, Lawrence F. Mgr., Wtr. & Lt. Plnt., P. O. Box 195, New Iberia, La.	May 27, 1922
Volkhardt, William. 535 Bay St., Stapleton, N. Y.	June 11, 1902
Von Greyerz, Walo, C.E. Capt. Royal Swedish Corps Engrs., Humlegardsgatan 29, Stockholm, Sweden.	July 23, 1920
Voris, Louis Robert. Consulting Chemist, Thomas Bldg., Hagerstown, Md.	Jan. 25, 1924
Vosbury, W. DeWitt. Hydraulic & Sanitary Engr., 509 Cooper St., Camden, N. J.	Jan. 19, 1924
Wachter, Leonard M. Chemist, Dept. of Health, 192 Partridge St., Albany, N. Y.	Mar. 16, 1922
Wade, B. F., C.E. 11 South LaSalle St., Chicago, Ill.	May 25, 1922
Wadsworth, G. A. Supt. Water Dept., Evanston, Ill.	May 16, 1918
Wagner, E. G. Supt. Water Works, City Hall, Lewiston, Idaho	Dec. 30, 1916
Wagner, Edwin B. Supt. Water Works, Downingtown, Pa.	Apr. 22, 1921
Wagner, H. F. Chemist Bureau of Water, Lab'y., Col. F. G. Ward Station, Buffalo, N. Y.	May 12, 1914
Wagner, Richard F. Supt. and Engr. Dept. of Water, Lynchburg, Va.	Nov. 3, 1919
Wahl, Benjamin. Chf. Chst. Detroit Sulph. P. & P. Co., Detroit, Mich.	June 8, 1923
Walden, A. E. Supt. & Chief Engineer, 26 Hamilton Ave., Raspeburg P. O., Baltimore, Md.	May 12, 1908
Walker, Carl C. Civil Engineer, 511–12 Hartman Bldg., Columbus, Ohio	Jan. 26, 1924
Walker, Elton D. Cons. Engr., Hydraulic and Sanitary Engr., 248 So. Burrowes St., State College, Pa.	July 18, 1907
Walker, Isaac S. Genl. Mgr. New Chester Wtr. Co., 594 Drexel Bldg., Philadelphia, Pa.	Mar. 25, 1919
Walker, Lewis Dewar. Wtr. Wks. Engr. Can. F. U. A., Excelsior Life Bldg., Toronto, Ont., Canada.	Feb. 10, 1921
Walker, Vincent E. 1606 Pennsylvania Ave., Wilmington, Del.	Nov. 20, 1923
Wall, Edward E. Water Comr., 312 City Hall, St. Louis, Mo.	June 7, 1904
Wall, W. A. General Manager, Water & Sewer Departments, King & Alakea Sts., Honolulu, T. H.	Apr. 10, 1922
Wallace, William M. Filter Supt. & Chief Chemist, Filtration Plant, Water Wks. Park, Detroit, Mich.	Apr. 5, 1922
Walsh, John H. Superintendent, Water Works, East Hartford Fire District, 265 Burnside Ave., East Hartford, Conn.	May 28, 1924
Ward, Charles Maxwell. Cons. Engr., 127 Stanley St., Montreal, P. Q., Canada	June 10, 1920
Ward, R. E. 17 Assylum St., Oxford, N. C.	May 16, 1923
Ward, Thomas H. City Commissioner No. 2, Public Wks., 1001 South 26th St., Fort Smith, Ark.	May 28, 1924

Warder, Charles. Superintendent Water Works, Niagara Falls, Ont., Canada	Jan. 8, 1916
Wardle, Andrew Nelson. San. Engr., Holway Engineering Co., Tulsa, Okla	Sept. 18, 1916
Waring, F. Holman. Asst. Engr. State Dept. of Health, Columbus, O	Feb. 23, 1915
Warren, C. A. Const. Engr., City Water Department, 1822 E. Lafayette Ave., Baltimore, Md	May 24, 1922
Warren, W. D. P. Cons. Engr., Milliken Bldg., Decatur, Ill.	Mar. 20, 1920
Warrick, Louis F. Asst. Sanitary Engineer, State Dept. of Health, Charleston, W. Va	Apr. 6, 1920
Waterman, Earle Lytton. Associate Professor San. Engr., 104 Eng. Hall, University Iowa, Iowa City, Iowa	Dec. 11, 1922
Watkins, Thomas. Mechanical Engr., Johnstown, Pa	May 18, 1892
Watkins, W. W. Chemist & Bact., Box 63, R.F.D.5., Norfolk, Va	June 5, 1922
Watson, George L. Cons. Engr., 150 Nassau St., New York, N. Y	Dec. 23, 1921
Watson, William. Supt., Water & Light Dept., City Hall, Owensboro, Ky	Mar. 8, 1924
Watt, D. M. Mgr. American Water Works & Elec. Co., 50 Broad St., New York, N. Y	Apr. 23, 1924
Watt, H. E. Supt. Huntington Water Corpn., Huntington, W. Va	Aug. 13, 1924
Watts, H. T., C.E. Supt. Wtr. Sup. Co., Box 107, Vincennes, Ind	July 7, 1920
Webb, S. W. Dist. Mgr. Consumers Power Co., Cadillac, Mich	Jan. 8, 1921
Weber, Joseph J. 344 Washington Rd., Sayreville, N. J	May 7, 1924
Webster, Edwin Roland. Cons. Engr., Webster Bldg., 327 S. LaSalle St., Chicago, Ill	Jan. 11, 1916
Wegman, Edward. Cons. Engr., 14 Morris Crescent, Yonkers, N. Y	June 11, 1902
Weidlein, E. R. Mellon Institute of Industrial Research, Thackeray & O'Hara Sts., Pittsburgh, Pa	June 26, 1924
Weir, W. V. 6600 Delmar Blvd., University City, Mo	July 14, 1924
Wells, George M. Consulting Engineer, 61 Broadway, New York, N. Y	May 5, 1913
Wells, James P. Cons. Hyd. Engr., 249 Cutler Bldg., Rochester, N. Y	Apr. 10, 1919
Wells, William Firth. Biologist & Sanitarian, Conservation Comn., Albany, N. Y	Mar. 16, 1922
Welsh, Russell Dutton. 919 W. Lenoir St., Raleigh, N. C.	July 14, 1923
Wentworth, Franklin H. Sect., National Fire Protection Assoc., 40 Central St., Boston, Mass	May 28, 1924
Wertz, Claude F. San. Engr., Engineering Division, Penna. Dept. of Health, Harrisburg, Pa	Mar. 25, 1924
Wesley, J. B. Chemist, Mo. Pacific R. R., 632 Railway Exc. Bldg., Kansas City, Mo	Apr. 24, 1922
West, Chas. C. Gen. Mgr., Sayre Water Co., Sayre, Pa.	Dec. 21, 1922
West, Geo. F. President, Biddeford and Saco Water Co., Portland, Me	July 24, 1911
West, George M. Supt., 182 So. Second St., Lehighton, Pa.	Mar. 17, 1916
West, Vernon F. Tres., Rensselaer Water Co., Box 868, Portland, Maine	June 19, 1914
Weston, Robert Spurr. Consulting Sanitary Engr., 14 Beacon St., Boston, Mass	June 15, 1898
Wetter, Clarence H. Supt. Water Works, Tiffin, Ohio	July 15, 1915
Wheeler, Robert C. Barker and Wheeler, 36 State St., Albany, N. Y	Oct. 23, 1914

WHEELER, WILLIAM. Consulting Civil Engr., 14 Beacon St., Boston, Mass.	July 10, 1906
WHIPPLE, GEORGE C. Cons. Engr., Pierce Hall, Harvard University, Cambridge, Mass.	June 7, 1904
WHIPPLE, MELVILLE C. Instructor in Sanitary Chemistry, 112 Pierce Hall, Cambridge, Mass.	May 13, 1922
WHITE, CHARLES H. Supt. Water Dept., Box 744, Asbury Park, N. J.	May 28, 1924
WHITE, GILBERT C., C.E. Durham, N. C.	May 12, 1908
WHITE, HENRY M. Supt., Water Works, Oneida, N. Y.	May 24, 1922
WHITE, I. A. Superintendent Water Works, Bessemer City, N. C.	Dec. 8, 1923
WHITEHOUSE, ORVILLE M. Supt. Filtn. Dutchess Bleachery, Wappingers Falls, N. Y.	Apr. 3, 1919
WHITLOCK, C. M. Supt. City Wtr. and Lt. Dept., Mt. Airy, N. C.	June 13, 1921
WHITMAN, EZRA B. Civil and Sanitary Engr., 1828 Munsey Bldg., Baltimore, Md.	Apr. 19, 1910
WHITLEY, L. G. 408 S. Tarboro St., Wilson, N. C.	May 28, 1924
WHITSIT, LAWRENCE C. City Engineer, 110 California Ave., Highland Park, Mich.	May 7, 1917
WHITTAKER, H. A. Director, Division of Sanitation, State Board of Health, Minneapolis, Minn.	June 24, 1913
WIDENHOUSE, E. A. Water & Light Dept., Albemarle, N. C.	Dec. 8, 1923
WIEGHARDT, GEO. F., C.E. Tech. Advisor & Bus Mgr. of Schools, Madison & Lafayette Aves., Baltimore, Md.	Mar. 25, 1924
WIETERS, A. H. State San. Engr., Waubay, S. D.	Nov. 14, 1921
WIGGIN, THOMAS H. Cons. Engr., 50 Church St., New York, N. Y.	May 24, 1922
WIGHT, H. C. P. O. Box 968, Dayton, Ohio	May 12, 1915
WIGLEY, CHESTER G., C.E. 66 Pierson Road, Maplewood, N. J.	Apr. 27, 1910
WILBUR, C. C. Asst. Engr. Minneap. Wtr. Dpt., 1229 Thomas Ave., N., Minneapolis, Minn.	Feb. 20, 1924
WILCOX, CLARK L. Treas., Pitt Construction Co., 6956 Thomas Blvd., Pittsburgh, Pa.	June 28, 1924
WILCOX, FRANK L. Cons. Engr., Chemical Building, St. Louis, Mo.	Apr. 28, 1914
WILCOX, WILLIAM F., M.E. 1206 Fourth National Bank Bldg., Atlanta, Ga.	Sept. 5, 1893
WILHELM, E. G. Secty-Treasr., Williamsport Water Co., Williamsport, Pa.	Feb. 15, 1917
WILHELM, GEORGE. Chief Engr. East Bay Water Co., Oakland, Cal.	Mar. 25, 1913
WILL, CHARLES K. Supt. Water Works, 118 S. Queen St., Lancaster, Pa.	Feb. 19, 1916
WILLARD, ERNEST C., C.E. 307 Corbett Bldg., Portland, Ore.	Oct. 10, 1914
WILLCOMB, GEORGE E. San. Engr., 12 So. Lyons Ave., Albany, N. Y.	Apr. 7, 1922
WILLETT, J. F. Supt. City Water Dept., Billings, Mont.	Apr. 28, 1915
WILLETT, WILLIAM N. Genl. Mgr. Murphysboro Wtr. Wks., Elect. and Gas. Light Co., Aurora, Ill.	Sept. 21, 1918
WILLIAMS, D. M. Assistant Engr., c/o Wm. M. Piatt, Durham, N. C.	May 18, 1923
WILLIAMS, GARDNER S. Cons. Engr., Cornwell Bldg., Ann Arbor, Mich.	July 10, 1906
WILLIAMS, HOWARD L. Supt. Water Works, Ludington, Mich.	Aug. 24, 1894
WILLIAMS, W. D. Supt. Water & Lights, State Hospital, Goldsboro, N. C.	Apr. 23, 1924
WILLIAMSON, D. CHARLES. 5 Orchard St., Bernardsville, N. J.	Jan. 16, 1923

Williamson, James E. Cons. Engr., 39 Cortland St., New York, N. Y. .... Jan. 20, 1921
Williamson, Lee H. Williamson, Carrol & Saunders, Natl. Bank Bldg., Charlottesville, Va. .... May 5, 1922
Willson, William Jay. Supt. Water Works, Greenwich, Conn. .... June 7, 1916
Wilson, I. E. Wtr. Commissioner, City Hall, Faribault, Minn. .... Sept. 21, 1922
Wilson, Jesse H., C.E. City Engineer, Idaho Falls, Ida. .... July 31, 1924
Wilson, John. 300 First Natl. Bank, Duluth, Minn. .... Dec. 22, 1909
Wilson, Norman McLeod Ramsay. Chf. Engr., Water Comnrs., Brantford, Ont., Canada .... Dec. 26, 1919
Wilson, O. L., Jr. Supt., Water Department, Smithfield, N. C. .... Dec. 8, 1923
Wilson, Rodney C. Supt. Water Works, Rockford, Ill. .... June 13, 1921
Wilson, William. Civ. and Cons. Engr., 209 Lincoln Ave., Youngstown, O., ... Dec. 16, 1919
Wingfield, Nisbet. Consulting Engr., Augusta, Ga. .... Dec. 9, 1910
Winslow, C.-E. A. Yale Medical School, New Haven, Conn. .... Jan. 30, 1915
Winslow, W. H. Vice Prest. Superior W., Lt. and Pr. Co., Superior, Wis. .... June 8, 1909
Winsor, Frank E. Chief Engr. Water Sup. Bd., 661 Westminster St., Providence, R. I. .... Jan. 26, 1924
Wintermute, Ferd C., C.E. 404 Second National Bank Bldg., Wilkes Barre, Pa. .... Dec. 16, 1922
Wintgens, Peter J. Supt. Wtr. Wks., 1201 Fifth Ave., Ford City, Pa. .... May 23, 1923
Wolbert, H. E. Supt. Bd. of Water Supply, Mount Vernon, N. Y. .... May 26, 1916
Wolf, H. Carl. Chief Engr. Public Serv. Comm., 1724 Munsey Bldg., Baltimore, Md. .... Feb. 27, 1924
Wolfe, Edward E. Chemist, Water Dept., Hannibal, Mo. .... Apr. 24, 1922
Wolfe, Nelson B., V.P. Geo. A. Johnson Co., 150 Nassau St., New York, N. Y. .... Mar. 12, 1924
Wolfe, Thomas F. Resrch. Engr., Cast Iron Pipe Pub. Bur. 566 Peoples Gas Bldg., Chicago, Ill. .... Mar. 16, 1922
Wolman, Abel. San. Engr., 16 West Saratoga St., Baltimore, Md. .... Mar. 11, 1918
Woltman, J. J., C.E. 225 Unity Bldg., Bloomington, Ill. .... May 20, 1923
Wood, Charles R. Melrose Park, Philadelphia, Pa. .... May 28, 1924
Wood, Leonard P. Asst. Engr., Board of Water Sup. of N. Y. C., 2217 Municipal Bldg., New York, N. Y. .... Mar. 5, 1924
Woods, Harland Clark. 442 Grove St., E. Lansing, Mich. .... Aug. 14, 1919
Woolfolk, Henry E. Supt. Water Works, Danville, Ky. .... May 22, 1912
Woolley, James. Meter Laboratory Chf., 135 4th St., Newark, N. J. .... June 21, 1920
Woolnough, Frederick, J. Designing Engineer, 392-8th St., Brooklyn, N. Y. .... Apr. 14, 1924
Worrell, M. L. Engr. and Mgr. City Wtr. Wks., Vicksburg, Miss. .... June 24, 1903
Worth, A. M. Supt., Filtration, c/o Water & Light Dept., Statesville, N. C. .... Apr. 23, 1924
Wright, E. L. Superintendent, Municipal Water Works, Orland, Glenn Co., Calif. .... June 20, 1922
Wright, Jas. Supt., Dundas Water Works, Dundas, Ont., Canada. .... Apr. 29, 1924
Wright, John G. Engr. and Filter Operator, 312 Lincoln St., Sayre, Pa. .... June 30, 1922
Wright, Stanley Hubert. Hyd. Engr., Gilbert C. White Co., P. O. Box 24, Henderson, N. C. .... July 13, 1923

Wyant, Carl. Resident Egr., Montecito County Water Dist., 29 San Ysido Rd., Santa Barbara, Calif..........	Mar. 5, 1924
Wyckoff, Charles Rapelye. Cons. Engr., 150 Nassau St., New York, N. Y....................................	Apr. 2, 1918
Wyckoff, Norman R. c/o Dept. of Water Supply, Detroit, Mich..	Sept. 11, 1923
Wynne-Roberts, R. O. 102 St. James Chambers, 88 Church St., Toronto, Ont., Canada........................	June 24, 1903
Yobst, Chas. B. Supt., Cons., 1804 Lumbard St., Fort Wayne, Ind..	Mar. 6, 1923
Younce, W. L. Superintendent City Water & Light Plant, Newcastle, Ind..................................	July 1, 1924
Young, C. H. Asst. Eng., Bureau of Engineering, Penna. Dept. of Health, Harrisburg, Pa.....................	May 28, 1924
Young, T. L. Mgr. South Side Water Works Co., Chester, W. Va..	June 13, 1921
Young, Wm. R. Registrar Water Works, City Hall, Minneapolis, Minn....	June 8, 1904
Zehr, Vratislav Adolph, M.E., C.E. Cons. Engr., Brandys Labe, Czechoslovakia..............................	Apr. 1, 1918
Zell, T. H. Superintendent Water Dept., Xenia, Ohio.....	May 23, 1923
Zimmerlin, Harry F. Supt. of Water, Lyons, N. Y.........	June 3, 1921

CORPORATE MEMBERS

Agua Pura Co. 701 Douglas Ave., East Las Vegas, N. M.	May 24, 1909
Alexandria Water Co. Alexandria, Va.	Apr. 3, 1909
Allentown Water Department. City Hall, Allentown, Pa.	May 31, 1922
American Water Works and Electric Co., Inc. Mr. H. Hobart Porter, Prest., 50 Broad St., New York, N. Y.	June 24, 1915
Anaconda Copper Mining Co. Water Works Dept., Anaconda, Mont.	June 4, 1910
Ann Arbor Water Works Commission. City Hall, Ann Arbor, Mich.	Apr. 14, 1919
Appleton Water Comn. City Hall, Appleton, Wis.	Aug. 23, 1921
Ashland Water Commission. E. C. Means, Chairman, Ashland, Ky.	Apr. 10, 1923
Ashtabula Water Supply Co., A. T. Faulkner, Manager, Ashtabula, Ohio	Mar. 5, 1924
Auburn Water Department. Auburn, New York	Mar. 8, 1911
Baton Rouge Water Works Co. Baton Rouge, La.	Apr. 13, 1914
Bear Gulch Water Company, Menlo Park, Calif.	Nov. 14, 1922
Benicia Water Co. J. A. Wilcox, Chf. Engr., 603 Wells Fargo Bldg., San Francisco, Cal.	May 29 1920
Birmingham Water Co. 22 Elizabeth St., Derby, Conn.	May 26, 1909
Bisbee-Naco Water Company, P. O. Box 1159, Bisbee, Ariz.	Sept. 8, 1924
Brampton Water Commission. Brampton, Ont., Canada	Feb. 28, 1923
Brantford Water Commissioners. Brantford, Ont., Canada	May 15, 1914
Buffalo, Bureau of Water, 2 Municipal Bldg., Buffalo, N. Y.	June 9, 1921
Canton Water Works. City Hall, Canton, Ill.	Oct. 14, 1914
Charleston Commissioners of Public Works, 14 George St., Charleston, S. C.	May 23, 1912
Chatham, Ont., Board of Water Commissioners. C. R. H. Fuller, City Mgr., Chatham, Ont., Canada	Feb. 16, 1924
Citizens Water Supply Co. Elmhurst, Long Island, N. Y.	Jan. 30, 1911
Columbia Water and Light Co. Columbia, Tenn.	Apr. 30, 1918
Connecticut State Dept. of Health. 8 Washington Street, Hartford, Conn.	Sept. 6, 1924
Conservative Water Co. 8619 Fir St., Los Angeles, Cal.	Nov. 3, 1919
Corning Water Works. Corning, N. Y.	Apr. 9, 1913
Davenport Water Co. Davenport, Iowa	July 7, 1919
Dayton Power & Light Co. 130 North South St., Att'n H. I. Fox, Supt., Wilmington, Ohio	Feb. 16, 1924
Delavan Water Commn. O. W. Blanchard, Supt., Delavan, Wis.	June 10, 1923
Deming Water Dept. Deming, N. Mex.	May 21, 1919
Dover Water Commissioners. Jos. V. Baker, Clerk, Dover Morris Co., N. J.	May 22, 1918
Dubuque City Water Works. J. W. McEvoy, Supt., Dubuque, Ia.	May 13, 1919
Dunbar Water Co. Dunbar, W. Va.	Mar. 19, 1924

Eagles Mere Water Co. 330 Pine St., Williamsport, Pa....	Apr. 10, 1914
East Bay Water Co. Oakland, Cal........................	June 24, 1915
East Orange Board of Water Commissioners. Paul C. Carey, President, East Orange, N. J..................	Aug. 14, 1909
Elmira Water Board. Elmira, N. Y......................	Mar. 11, 1915
Emporia Water Department. City Bldg., Emporia, Kans..	Jan. 16, 1924
Erie Commissioners Water Works. 701 French St., Erie, Pa.	May 31, 1911
Evansville Water Works. Evansville, Ind................	May 7, 1909
Federal Light and Traction Co. 52 William St., New York, N. Y..	Mar. 8, 1920
Fond du Lac City Water Dept. J. J. Breister, Supt., Fond du Lac, Wis..	May 22, 1919
Glen Ridge Water Department. William Dewar, Supt., Glen Ridge, N. J...............................	Oct. 27, 1922
Glendale, Calif., Public Service Dept. 575 Broadway, Glendale, Calif....................................	Dec. 24, 1914
Glens Falls Board of Water Commissioners. Glens Falls, N. Y..	Oct. 24, 1918
Grand Rapids Department of Public Service. Grand Rapids, Mich...	Feb. 14, 1913
Green Bay Water Dept. James Church, Supt., Green Bay, Wis...	Nov. 3, 1914
Griffin Light, Water & Sewerage Dept. Griffin, Georgia.	Feb. 16, 1924
Guelph Water Works Dept. Mr. G. D. Hastings, City Mgr., City Hall, Guelph, Canada......................	Mar. 25, 1924
Hopkinsville Water Co. Hopkinsville, Ky................	Apr. 23, 1915
Hot Springs Water Co. Hot Springs, Ark.................	Mar. 8, 1920
Idaho Surveying & Rating Bureau. P. O. Box 1059, Boise, Idaho..	Feb. 9, 1924
Ilion Board of Water Commissioners. Ilion, N. Y........	Mar. 31, 1924
Illinois Inspection Bureau. 37 South Wabash Ave., Chicago, Ill..	Jan. 30, 1924
Illinois Power & Light Corp. Compton Bldg., St. Louis, Mo..	Mar. 26, 1920
Industrial Serv. Corp. of Va. Hopewell, Va..............	Feb. 22, 1922
Interstate Public Service Co. New Albany, Ind..........	Feb. 10, 1910
Ironwood Water Dept. Dow I. Sears, Ironwood, Mich.....	May 17, 1923
Kansas City Water Commission. City Hall, Kansas City, Mo..	Feb. 8, 1915
Kennebec Water Dist. Mr. George K. Boutelle, Treasr., Waterville, Maine..................................	May 12, 1908
Kentucky State Board of Health. F. C. Dugan, Dctr. Bur. San. Eng., 532 W. Main St. Louisville, Ky.......	Feb. 5, 1915
Kentucky Utilities Co., Marion E. Taylor Bldg., Louisville, Ky..	Feb. 13, 1924
Keyser, City of. L. R. Warner, City Clerk, 64 N. Mineral St., Keyser, W. Va..................................	Feb. 20, 1924
Kingsport Utilities, Inc., Kingsport, Tenn...............	Sept. 18, 1921
Kitchener Water Commission. Kitchener, Canada........	Feb. 17, 1920
Knoxville Water Dept. Knoxville, Tenn.................	May 23, 1923
Lake Charles Railway, Light and Water Works Co. Lake Charles, La..	Apr. 29, 1910
Lanett Cotton Mill. M. R. Wallis, West Point, Georgia...	Mar. 1, 1924
Lewistown-Reedsville Water Co. Lewistown, Pa.......	May 14, 1922

Lincoln City Water and Ltg. Dept. City Hall, Lincoln, Neb.	Mar. 6, 1919
Lockport Board of Water Commissioners. Lockport, N. Y.	Apr. 9, 1924
London. Canada, Public Utilities Commission. London Canada.	Apr. 9, 1909
Lorain Water Works. Lorain, Ohio.	July 14, 1916
Los Angeles Bureau of Water Works and Supply. Box 497, Los Angeles, Calif.	Apr. 18, 1910
Louisville Water Co. 435 So. Third St., Louisville, Ky.	Apr. 9, 1909
Mahoning Valley Water Co. Jas. J. McNally, Scty. and Tr., Youngstown, Ohio.	July 26, 1916
Malmo Byggnadskontor. Alfred Jerden, Chf. Engr., Malmo, Sweden.	July 23, 1921
Marion Water Co. George Whysall, Supt. Marion, Ohio.	Mar. 3, 1917
Massillon Water Supply Co. Watson A. Dark, Supt., Massillon, O.	June 8, 1921
Meigs Water Co. C. M. Herminy, Gen. Mgr., Middleport, Ohio.	Feb. 23, 1924
Memphis Board of Water Commissioners. Memphis, Tenn.	Apr. 2, 1909
Metropoln. Bd. Water Supply and Sewage. 341 Pitt St., Sydney, N. S. W.	Aug. 31, 1909
Metropolitan Utilities District. Omaha, Neb.	Apr. 28, 1912
Michigan State Board of Health Lansing, Mich.	July 13, 1917
Middletown Water Works. J. Warren Mylchreest, Middletown, Conn.	June 8, 1921
Millville Water Co. Millville, N. J.	Jan. 11, 1916
Minneapolis Committee on Water Works. Wm. R. Young, Registrar, Minneapolis, Minn.	June 17, 1920
Minnesota General Inspection Bureau. Lock Drawer 1746, Minneapolis, Minn.	Feb. 9, 1924
Moline Water Department, City Hall, Moline, Ill.	Jan. 29, 1916
Mount Carmel Water Co. Mount Carmel, Pa.	May 7, 1904
Mount Holly Water Co. Mount Holly, N. J.	Apr. 30, 1924
Muscatine Water Trustees. Muscatine, Ia.	May 9, 1921
New Jersey Dept. Conservation and Development. H. T. Critchlow, H. E., State House, Trenton, N. J.	Jan. 26, 1922
Northampton Consolidated Water Co. 102 So. 3rd St., Easton, Pa.	Dec. 5, 1915
Ohio Inspection Bureau. Hartman Bldg., Columbus, Ohio.	Jan. 30, 1924
Oswego Department of Water. Oswego, N. Y.	June 1, 1921
Owego Water Works Co. Owego, N. Y.	Apr. 16, 1914
Pennichuck Water Works. 11 High St., Nashua, N. H.	Oct. 30, 1914
Peterborough Utilities Commission. R. L. Dobbin, Waterworks Superintendent, 622 George St., Peterborough, Ont., Canada.	May 2, 1911
Pine Bluff Co. J. L. Longino, Secty., Pine Bluff, Ark.	May 18, 1904
Portland Dept. of Public Utilities. Room 302, City Hall, Portland, Ore.	Dec. 17, 1917
Poughkeepsie Board of Public Works. Water Department, Poughkeepsie, N. Y.	Dec. 11, 1922
Public Service Co. of No. Ill. 72 W. Adams St., Chicago, Ill.	June 10, 1911
Public Utilities Co., The. Carlsbad, N. Mex.	Feb. 27, 1924
Quincy Water Works Commission. 314 Maine St., Quincy, Ill.	Apr. 4, 1924

Raymond, Wash., Water Department. L. D. Kelsey, City Engr., Raymond, Wash.	Apr. 2, 1923
Regina, Sask., Waterworks Department. City Hall, Regina, Sask., Canada	Apr. 4, 1924
Rome, N. Y., Department of Public Works. Bureau of Water, Rome, N. Y.	Apr. 25, 1922
Saginaw Water Dept. Saginaw, Mich.	Apr. 12, 1904
Salt Lake City Wtr. Dept. H. K. Burton, Supt., Salt Lake City, Utah	Feb. 17, 1920
San Jose Water Co. San Jose, Cal.	Apr. 21, 1913
Sandusky, Ohio. O. F. Schoepfle, Filtration Plant, Meigs St., Sandusky, Ohio	June 9, 1921
Santa Fe Water & Light Co. Edgar L. Street, V. P., Santa Fe, New Mex.	Mar. 12, 1924
Scranton Gas and Water Co. 135 Jefferson Ave., Scranton, Pa.	June 3, 1912
Sea Breeze & Vicinity Wtr. Comn. Henry Fleig, Sect., Point Pleasant, Monroe Co., N. Y.	Feb. 23, 1920
Sharon Water Works Co. 24 So. Dock St., Sharon, Penna.	Apr. 10, 1922
Sheboygan Board of Water Comnrs. City Hall, Sheboygan, Wis.	June 21, 1920
Shenandoah, Commissioners of Water Works. C. Pavitt, Secy., 101 S. Jardin St., Shenandoah, Pa.	May 19, 1924
Sherrill-Kenwood Water Commission. Stephen R. Leonard, Chairman, Kenwood, Oneida, N. Y.	Apr. 24, 1921
Spokane, Wash., Superintendent Water Division. Room 303, City Hall, Spokane, Wash.	Apr. 5, 1912
St. Lawrence Water Co. Massena, N. Y.	Apr. 4, 1924
St. Mary's Ont., Board of Water Light & Heat Comn. Box 333, St. Mary's Ont., Canada	Nov. 3, 1919
St. Thomas Water Commissioners. St. Thomas, Ont., Canada	Apr. 11, 1909
Stockton Water Co. 315 Market St., Camden, N. J.	Jan. 11, 1918
Suburban Water Co. of Allegheny County. Verona, Pa.	Apr. 10, 1909
Syracuse Bureau of Water. Syracuse, N. Y.	Jan. 16, 1923
Taxpayers Municipal Water Works. Creston, Iowa	May 10, 1909
Topeka City Water & Light Dept. Topeka, Kans.	Mar. 12, 1924
Toronto, Ohio, Board of Public Affairs. J. B. Thompson, Supt., Toronto, Ohio	Feb. 23, 1924
Totowa, Borough of. Totowa, N. J.	Oct. 20, 1920
Trenton Water Works. Trenton, N. J.	May 8, 1909
Trotter Water Co. C. L. Farson, Supt., Uniontown, Pa.	July 26, 1921
Troy Bureau of Water. William F. End, Troy, N. Y.	May 28, 1924
Truckee River Power Co. Reno, Nev.	Feb. 4, 1913
Urban Water Supply Co. Maurice and Borden Ave., Maspeth, L. I.	Oct. 20, 1912
Utrechtsche Waterleiding. Maatschappij, Utrecht, 15 Predikheerenkerkhof, Holland	Nov. 9, 1922
Vallejo City Water Dept. Alf E. Edgcumbe, City Clerk, City Hall, Vallejo, Calif.	June 11, 1924
Vinton-Roanoke Water Co. Francis W. Collins, Cons. Engr., 452 Lexington Ave. Gr. Cent. Term., New York, N. Y.	Dec. 3, 1904
Waco Water Works. 617 Washington Ave., Waco, Texas	Apr. 16, 1910
Wahiawa Water Co., Ltd. Wahiawa, Oahu, T. H.	Apr. 20, 1923

WATERTOWN WATER WORKS. Watertown, N. Y.	June 8, 1909
WELLAND BOARD OF WATER COMN. C. R. Hagan, Chmn., Welland, Ont., Canada	May 7, 1920
WEST CHESTER, BOROUGH OF. West Chester, Pa.	June 15, 1922
WEST NEWTON WATER CO. West Newton, Pa.	May 24, 1922
WEST VIRGINIA UTILITIES CO. Morgantown, W. Va.	Feb. 23, 1924
WEST VA. WATER AND ELECTRIC CO. A. C. Babson, V. P. and Gl. Mgr., Charleston, W. Va.	Sept. 4, 1911
WESTERN NEW YORK WATER CO. 704 Electric Building, Buffalo, N. Y.	Apr. 15, 1913
WHITBY PUBLIC UTILITY COMMISSION. Attn's George W. P. Every, Supt., Municipal Waterworks Dept., Whitby, Ont., Canada	Feb. 23, 1924
WHITE DEER MOUNTAIN WATER CO. 114 So. Front St., Milton, Pa.	May 5, 1914
WHITE PLAINS DEPT. OF PUBLIC WKS. Wm. H. Lyon, Comr. in charge of Water Works, White Plains, N. Y.	July 31, 1916
WILLIAMSPORT WATER CO. 330 Pine St., Williamsport, Pa.	Apr. 15, 1907
WINDSOR WATER COMMISSIONERS. Windsor, Ont.	Feb. 19, 1923
WINNETKA, VILLAGE OF. Winnetka, Ill.	June 21, 1909
WINONA BOARD OF MUNICIPAL WORKS. Winona, Minnesota	Dec. 11, 1922
YOUNGSTOWN CITY WATER DEPT. H. F. Kaercher, Supt., Youngstown, O.	June 10, 1919

ASSOCIATE MEMBERS

Acker, William L. Mech. Engr., 725 W. Lackawanna Ave., Scranton, Pa.	Apr. 23, 1924
Adams, Lee F. El. Engr., Pwr. and Mng. Eng. Dept., General Electric Co., Schenectady, N. Y.	June 1, 1921
Allis-Chalmers Mfg. Co. Milwaukee, Wis.	June 24, 1905
Ambursen Construction Co., Inc. Grand Central Terminal Bldg., New York, N. Y.	Jan. 29, 1921
American Brass Co. Sales Dept., Waterbury, Conn.	Aug. 10, 1922
American Cast Iron Pipe Co. Birmingham, Ala.	July 18, 1907
American City. 443 Fourth Ave., New York, N. Y.	May 25, 1918
American Foundry and Mfg. Co. 10th, 11th, Hebertt and Wright Sts., St. Louis, Mo.	May 12, 1908
American Manganese Bronze Co. Holmesburg, Philadelphia, Pa.	May 9, 1916
American Pipe and Constn. Co. 112 N. Broad St., Philadelphia, Pa.	May 1, 1909
American Steel and Wire Co. Chemical and Color Dept., 208 South LaSalle St., Chicago, Ill.	June 24, 1903
American Water Softener Co. Lehigh Ave. & Fourth St., Philadelphia, Pa.	July 14, 1923
American Well Works. Aurora, Illinois.	Mar. 21, 1923
American Zeolite Corp. East 11th St. & Fifth Ave., Paterson, N. J.	May 28, 1924
Arnold, Hoffman and Co., Inc. 18th Floor, 350 Madison Ave., New York, N. Y.	Nov. 21, 1913
Art Concrete Works. Mfrs. Meter Boxes, P. O. Box 417, Pasadena, Cal.	Dec. 13, 1920
Automatic Primer Co. F. H. Bradford, Pres., 111 W. Washington St., Chicago, Ill.	Apr. 4, 1924
Babcock and Wilcox Co. J. B. Romer, Chemist, Bayonne, N. J.	May 28, 1924
Badger Meter Mfg. Co. 841–7 Thirtieth St., Milwaukee, Wis.	June 8, 1904
Bayard, M. L. Prest., 20th St. & Indiana Ave., Philadelphia, Pa.	Mar. 31, 1922
Birch Manufacturing Co. 1521–1523 Sedgwick St., Chicago, Ill.	May 11, 1916
Bourbon Copper and Brass Works Co. 618 E. Front St., Cincinnati, Ohio	Apr. 17, 1884
Bowler Foundry Co. 1688 Columbus Road, Cleveland, Ohio	July 6, 1922
Buckeye Traction Ditcher Co. C. D. Royce, Sales & Avd. Mgr., Findlay, Ohio	May 26, 1920
Buffalo Meter Co. 2917 Main St., Buffalo, N. Y.	June 27, 1905
Builders Iron Foundry, 9 Codding St., Providence, R. I.	June 18, 1901
Byers, A. M., Co. 235 Water St., Pittsburgh, Pa.	June 15, 1921
"Canadian Engineer." Church and Court Sts., Toronto, Ont., Can.	May 31, 1916
Central Foundry Co. Liggett Bldg., 41 E. 42nd St., New York, N. Y.	June 24, 1903

Chain Belt Co. R. A. Corbett, Sales Dept., Milwaukee, Wis.	Apr. 10, 1920
Chapman Valve Mfg. Co. Indian Orchard, Mass.	Apr. 16, 1884
Chase Metal Works. 236 Grand Street, Waterbury, Conn.	Sept. 21, 1922
Chicago Bridge and Iron Co. 608 South Dearborn St., Chicago, Ill.	June 15, 1908
Clark, H. W., Co. 115 South 17th St., Mattoon, Ill.	May 12, 1908
Clow, J. B., and Sons, Harrison and Franklin Sts., Chicago, Ill.	Apr. 27, 1885
Cochrane Corpn.—H.S.B.W. 3146 N. 17th St., Philadelphia, Pa.	May 2, 1922
Coffin Valve Co., Neponset, Mass.	May 21, 1922
Cohoes Rolling Mill Co. Canvass and Cortland Sts., Cohoes, N. Y.	Jan. 2, 1924
Coldwell-Wilcox Co. Newburgh, N. Y.	Apr. 17, 1914
Colorado Fuel and Iron Co. Denver, Colo.	June 7, 1897
Columbian Iron Works. Chattanooga, Tenn.	Apr. 4, 1910
Conover and Phillips. Specialists in Water Securities, 141 Broadway, New York, N. Y.	June 13, 1924
Cook, A. D., Inc. Manfacturer of Deep Well Pumps and Strainers, Lawrenceburg, Ind.	June 14, 1914
Copper and Brass Assoc. Wm. G. Schneider, 25 Broadway, New York, N. Y.	Aug. 28, 1923
Darling Valve and Man'fg. Co. Williamsport, Penna.	May 12, 1908
Dayton-Dowd Co. Quincy, Ill.	July 5, 1922
De Laval Steam Turbine Co. H. L. Watson, Sales Mgr., Trenton, N. J.	Nov. 23, 1917
Digestive Ferments Co. 920 Henry St., Detroit, Mich.	Mar. 26, 1923
Dixon, Joseph, Crucible Co. Jersey City, N. J.	May 8, 1915
Donaldson Iron Co. Emaus, Lehigh Co., Pa.	Nov. 23, 1917
Dravo-Doyle Co. J. D. Berg, Vice-Prest., Diamond Bank Bldg., Pittsburgh, Pa.	May 12, 1914
Dresser, S. R., Mfg. Co. Mfgr. Pipe Couplings and Sleeves, Bradford, Pa.	June 7, 1904
Drummond, McCall and Co., Ltd. Toronto, Ont., Canada.	Mar. 5 1921
du Pont de Nemours, E. I. & Co. W. E. Donohoe, Sales Mgr., 3500 Grays Ferry Road, Philadelphia, Pa.	May 12, 1908
East Jersey Pipe Co. 7 Dey St., New York, N. Y.	July 10, 1906
Edson Manufacturing Corp. 375 Broadway, Boston '11', Mass.	Mar. 21, 1923
Eddy Valve Co. Waterford, N. Y.	June 26, 1886
Electro Bleaching Gas Co., 9 E. 41st St., New York, N. Y.	Qpr. 2, 1913
Electrolytic Chlorine Co. Albert M. Williams, Pres., 5730 Virginia St., Kansas City, Mo.	June 1, 1923
Elliott-Fisher Co. Edw. A. Norman, Sales Mgr., 342 Madison Ave., New York, N. Y.	Apr. 30, 1923
"Engineering and Contracting." 221 E. 20th St., Chicago, Ill.	May 13, 1918
"Engineering News-Record." 10th Ave. at 36th St., New York, N. Y.	May 31, 1918
Farnan Brass Works Co. 1104 Center St., Cleveland, Ohio.	May 18, 1892
Federal Meter Co. 838–844 Fourth Ave., Brooklyn N. Y.	May 23, 1923
"Fire and Water Engineering." 318 W. 39th St., New York, N. Y.	June 28, 1919
Fleischmann Co. Peekskill, N. Y.	June 15, 1922
Ford Meter Box Co. Wabash, Ind.	May 12, 1908

Forni Manufacturing Co., 1377 62nd St., Oakland, Cal....	Aug. 28, 1924
Fox, John, and Co. 233 Broadway, New York City, N. Y....	June 8, 1909
Gamon Meter Co. Newark, N. J..........................	May 19, 1920
General Chemical Co. 112 West Adams St., Chicago, Ill....	June 11, 1902
Gillespie, T. A. Chrmn. T. A. Gillespie Co., 7 Dey St., New York, N. Y..................................	June 7, 1904
Glamorgan Pipe and Foundry Co. Lynchburg, Va.........	Nov. 6, 1907
Glauber Brass Mfg. Co. Platt Ave. and East 79th St., Cleveland, Ohio..................................	May 13, 1914
Grinnell Co., Inc. Cullen L. Korner, Box 336, Charlotte, N. C..	May 17, 1923
Gurley, W. and L. E. 514 Fulton St., Troy, N. Y...........	Apr. 16, 1919
Hankin, Francis, and Co., Ltd. 598–604 Union Ave., Montreal, Canada..................................	June 19, 1920
Hays Mfg. Co. Erie, Pa	Mar. 15, 1882
Herman Chemical Corp., K. I. Matteson, Cook Co., Ill....	Oct. 24, 1923
Hersey Mfg. Co. South Boston, Mass....................	July 14, 1887
Hooker Electrochemical Co. G. F. Reale, 25 Pine St., New York, N. Y..................................	July 7, 1920
Ingersoll, Rand Co. 11 Broadway, New York City	Oct. 31, 1922
International Filter Co. 329–337 25th Place, Chicago, Ill...	Nov. 3, 1915
Jenkins Bros., Ltd. 103 St. Remi St., Montreal, Canada...	May 20, 1920
Johnson, Edward E., Inc. 2304 Long Ave., St. Paul, Minn..	May 17, 1922
Jones, James, Co. W. B. Jones, Secty., 201 Leroy St., Los Angeles, Cal..................................	Oct. 20, 1921
Kalbfleisch Corporation. 200 Fifth Ave., New York City, N. Y..	June 8, 1909
Kelly Well Co. 112½ E. Third St., Grand Island, Nebr.....	Jan. 7, 1924
Kennedy Valve Mfg. Co. M. E. Kennedy, Treasr., Elmira, N. Y..	Mar. 24, 1911
Keystone Iron and Steel Works. 2951–3641 Santa Fe Ave., Los Angeles, Cal..................................	Jan. 20, 1920
Kraus, Charles E. Pres., Kraus Research Laboratories, Inc., 110 W. 40th St., New York, N. Y................	June 11, 1924
Lap-Joint Impervious Pipe Co. 591 Washington St., Lynn, Mass..	May 28, 1924
Layne and Bowler Co. Memphis, Tenn....................	June 5, 1916
Lead Lined Iron Pipe Co. Wakefield, Mass................	Oct. 5, 1898
Leadite Company, Inc. Land Title Building, Philadelphia, Pa..	Feb. 10, 1910
Lock Joint Pipe Co. Box 21, Ampere, N. J.	Oct. 5, 1915
Ludlow Valve Mfg. Co. Troy, N. Y.......................	Mar. 5, 1882
Lynchburg Foundry Co. Lynchburg, Va..................	June 6, 1916
McGowan, John H., Co. Second and Central Ave., Cincinnati, Ohio..	May 26, 1913
McWane Cast Iron Pipe Co. Birmingham, Ala	Apr. 23, 1923
Mabbs Hydraulic Packing Co. 431 So. Dearborn St., Chicago, Ill..................................	May 7, 1923
MacLean, Hugh C., Publications, Ltd. Pblr. Trade and Tech. Jls., 347 Adelaide St. W., Toronto, Ont., Canada...	June 2, 1920
Mathieson Alkali Works, Inc. 25 West 43rd St., New York, N. Y..	Mar. 16, 1920

MICHIGAN VALVE & FOUNDRY CO. 3631 Parkinson Ave., Detroit, Mich. ..... June 7, 1919
MODERN IRON WORKS. Quincy, Ill. ..... June 27, 1905
MONTAGUE PIPE AND STEEL CO. 803 Hobart Building, San Francisco, Calif ..... Dec. 31, 1922
MORRIS MACHINE WKS. Baldwinsville, N. Y. ..... July 31, 1923
MUELLER, CO. Decatur, Ill. ..... Mar. 15, 1882
MULTIPLEX MFG. CO. Multiplex Bldg.. Berwick, Pa. ..... May 7, 1916
MURRAY IRON WORKS CO. Burlington, Iowa. ..... Mar. 6, 1923

NATIONAL CAST IRON PIPE CO. E. E. Linthicum, Pres., Birmingham, Ala. ..... May 17, 1916
NATIONAL IRON CORPN., LTD. Cherry St., Toronto, Ont. ..... Oct. 22, 1921
NATIONAL METER CO. 299 Broadway, New York, N. Y. ..... Mar. 15, 1882
NATIONAL SUPPLY CO. E. J. Bissonnette, Salesman, 1321 Prospect Ave., Toledo, O. ..... Apr. 10, 1924
NATIONAL TUBE CO. W. L. Schaeffer, 1902 Frick Bldg., Pittsburgh, Pa. ..... May 18, 1921
NATIONAL WATER MAIN CLEANING CO. 50 Church St., New York, N. Y. ..... July 10, 1906
NELSON, JOS. E., AND SONS. Contractors, 3240 S. Michigan Ave., Chicago, Ill. ..... Sept. 7, 1919
NEPTUNE METER CO. 50 East 42nd St., New York, N. Y. ..... Aug. 22, 1894
NEPTUNE METER CO., LTD. 1195–7 King St. West, Toronto, Ont., Canada. ..... Apr. 2, 1920
NEWARK BRASS WORKS. 16–22 Lawrence St., Newark, N. J. May 12, 1923
NORTHERN FIRE APPARATUS CO. 920 18th Ave., N. E., Minneapolis, Minn. ..... Mar. 31, 1924
NORWOOD ENGINEERING CO. Florence, Mass. ..... May 26, 1919

PARSONS, KLAPP, BRINCKERHOFF & DOUGLAS. Cons. Engrs., 84 Pine St., New York, N. Y. ..... July 26, 1922
PAYNE, DEAN, LIMITED. Stamford, Conn. ..... Mar. 18, 1921
PENNSYLVANIA SALT MFG. CO. Widener Building, Philadelphia, Pa. ..... June 24, 1903
PERMUTIT CO. 440 Fourth Ave., New York, N. Y. ..... Mar. 11, 1914
PITOMETER CO. 50 Church St., New York, N. Y. ..... July 10, 1906
PITTSBURGH-DES MOINES STEEL CO. Pittsburgh, Pa. ..... Apr. 14, 1914
PITTSBURGH METER CO. Wilkinsburg Branch P. O., Pittsburgh, Pa. ..... June 15, 1898
PITTSBURGH TESTING LABORATORY. P. O. Box 1115, Pittsburgh, Pa. ..... May 8, 1915
PORTLAND CEMENT ASSOCIATION. 111 W. Washington St., Chicago, Ill. ..... Oct. 23, 1917
"PUBLIC WORKS." 243 West 39th St., New York, N. Y. ..... May 25, 1918

R. U. V. COMPANY. 7 Burritt Ave., South Norwalk, Conn. ..... June 6, 1917
RENSSELAER VALVE CO. Troy, N. Y. ..... May 12, 1890
RITER CONLEY CO. Box 939, Pittsburgh, Pa. ..... June 11, 1924
ROBERTS, CHARLES V. Prest., Roberts Filter Mfg. Co., Darby, Philadelphia, Pa. ..... Mar. 23, 1910
ROSS VALVE MFG. CO., INC. Oakwood Ave., Troy, N. Y. ..... Apr. 18, 1891

SANITATION CORPORATION. 165 Broadway, New York, N. Y. Apr. 27, 1915
SAVAGE, W. J., CO. Knoxville, Tenn. ..... May 31, 1919
SCOFIELD ENGINEERING CO. 1324 Commercial Trust Bldg., Philadelphia, Pa. ..... June 7, 1921
S. E. T. VALVE & HYDRANT CO. 50 Church St., New York, N. Y. ..... Apr. 14, 1924

SENTRY METER CO. 2410 First National Bank Bldg., Detroit, Mich.	May 27, 1924
SIMPLEX VALVE AND METER CO. 5722 Race St., Philadelphia, Pa.	May 14, 1914
SIMS PUMP VALVE CO. 2 Rector St., New York, N. Y.	Mar. 23, 1922
SIRCH, C. W. Suite 300–301 Lankersheim Bldg., Los Angeles, Calif.	Sept. 25, 1923
SMITH, A. P., MFG. CO. East Orange, N. J.	June 7, 1897
SULLIVAN MACHINERY CO. 122 S. Michigan Ave., Chicago, Ill.	Mar. 31, 1915
TAYLOR, W. P., CO. 218 Ellicott Square, Buffalo, N. Y.	Mar. 15, 1882
THOMSON METER CO. 100 Bridge St., Brooklyn, N. Y.	Apr. 15, 1891
TRAVERSE CITY IRON WORKS. 129 Lake Ave., Traverse City, Mich.	Apr. 29, 1924
UNION WATER METER CO. 33 Hermon St., Worcester, Mass.	Mar. 15, 1882
UNITED BRASS MFG. CO. 3844 Hamilton Ave., Cleveland, Ohio	May 25, 1914
UNITED LEAD COMPANY. 111 Broadway, New York, N. Y.	May 12, 1908
UNITED STATES CAST IRON PIPE AND FOUNDRY CO. 1421 Chestnut St., Philadelphia, Pa.	June 11, 1892
VAN GILDER WATER METER CO. Chester & Grant Aves., Pleasantville, N. J.	Mar. 31, 1924
VOORHEES RUBBER MFG. CO. 20–56 Bostwick Avenue, Jersey City, N. J.	Jan. 4, 1923
WALLACE AND TIERNAN CO., INC. Box 178, Newark, N. J.	Apr. 23, 1915
WARREN FOUNDRY AND PIPE CO. 11 Broadway, New York, N. Y.	Mar. 4, 1911
WATER WORKS EQUIPMENT CO. Rooms 1950–51, 50 Church St., New York, N. Y	July 10 1906
WEEKES JOHN, & SON CO. Glenn R. Shriver, Gen. Mgr., 224 Factory St., Watertown, N. Y.	Apr. 4, 1924
WESTERN PIPE & STEEL CO., OF CALIF. 444 Market St., San Francisco, Calif.	Aug. 13, 1924
WHITE, J. G., ENG. CORP. 43 Exchange Place, New York, N. Y.	Mar. 31, 1921
WOOD, R. D., AND CO. 400 Chestnut St., Philadelphia, Pa.	Apr 16, 1884
WORTHINGTON PUMP AND MACH'Y CORP. 115 Broadway, New York, N. Y.	June 18, 1901
WYCKOFF, A., AND SON CO. Elmira, N Y.	July 18, 1907

GEOGRAPHICAL DISTRIBUTION

ALABAMA

Active 9; Associate 3; Total 12

ACTIVE

Alexander City: Robinson.
Birmingham: Decker, Sweet, Totten.
Mobile: Soost.
Montgomery: Hazlehurst.
Muscle Shoals: Mickle.
Sheffield: Gammon.
Tuscaloosa: Abbott.

ASSOCIATE

Birmingham: American Cast Iron Pipe Co., E. E. Linthicum, Pres., National Cast Iron Pipe Co., McWane Cast Iron Pipe Co.

ARIZONA

Active 3; Corporate 1; Total 4

Ajo: DuMoulin.
Prescott: Shaw.
Tucson: Rider.

CORPORATE

Bisbee: Bisbee-Naco Water Co.

ARKANSAS

Active 3; Corporate 2; Total 5

ACTIVE

Fort Smith: Ward.
Little Rock: Bair, Johnson.

CORPORATE

Hot Springs: Hot Springs Water Co.
Pine Bluff: Pine Bluff Co.

CALIFORNIA

Honorary 1; Active 81; Corporate 8; Associate 7; Total 97

HONORARY

Los Angeles: Mulholland.

ACTIVE

Albany: Costa.
Alhambra: Hilton.
Atascadero: Robinson.
Berkeley: Hyde, Klaus, Langlier, Reinke.
Compton: Parrish.
Dixon: Sedgwick.
Fresno: Jackson.
Hanford: Isaac, Johns.
Hayward: Smalley.
Inglewood: Farmer.
Los Angeles, Barnard, Cates, Finkle, Goudey, Hurlbut, Lawton, Moore, Mudge, Rowe, Slater, Stone, Taylor.
Marysville: Belcher.
Monrovia: Given.
Oakland: Chamberlain, Davis, Gillespie, Hawley, Hunter, Magestadt, Reinhardt, Wilhelm.
Ontario: Roen.
Orlando: Wright.
Pacific Grove: Olmstead.
Pasadena: Allin, Morris.
Sacramento: Jenks, Nickerson, Prugh.
San Diego: Ervast, Lovell.
Salinas: Snell.
San Francisco: Abbott, Andrews, Bragg, Clemens, Elliott, Ellis, Flaa, Graff, Hammerly, Hommon, Hunter, Kempkey, Lee, Luippold, Mars, Martindale, McCaughern, Mendelsohn, O'Shaughnessy, Pracy, Sharon, E. H. Shibley, Kenneth Shibley.
San Jose: Ford.
San Rafael: Burt, Everett, Longland.
Santa Barbara: Trace, Wyant.
Santa Paula: Giacomazzi.
Stockton: Fagg.
Turlock: Brown.
Vacaville: Eldredge.
Watsonville: Kitchen.

CORPORATE

Glendale: Public Service Dept.
Los Angeles: Bureau of Water Works and Supply, Conservative Water Co.
Menlo Park: Bear Gulch Water Co.
Oakland: East Bay Water Co.

San Francisco: Benicia Water Co.
San Jose: San Jose Water Co.
Vallejo: Vallejo City Water Dept.

ASSOCIATE

Los Angeles: James Jones Co., Keystone Iron and Steel Works, C. W. Sirch.
Oakland: Forni Mfg. Co.
Pasadena: Art Concrete Works.
San Francisco: Montague Pipe and Steel Co., Western Pipe & Steel Co. of Calif.

COLORADO

Active 9; Associate 1; Total 10

ACTIVE

Colorado Springs: McReynolds.
Denver: Lowther, Miller, Rathbun, Robinson, Vail.
Pueblo: Porter, Stone.
Rocky Ford: Strouse.

ASSOCIATE

Denver: Colorado Fuel and Iron Co.

CONNECTICUT

Active 22; Corporate 3; Associate 4; Total 29

ACTIVE

Ansonia: Davis.
Bridgeport: Senior.
Bristol: Lourie.
Danbury: Raymond.
Fairfield: Cowles.
Greenwich: Wilson.
Hartford: Berry, Newlands, Peck, Purcell, Saville, Scott, Walsh.
New Haven: Gaillard, Glynne, Hill, Minor, Winslow, Southington, MacKenzie.
Thompsonville: Schwabe.
Torrington: Travis.

CORPORATE

Derby: Birmingham Water Co.
Hartford: Connecticut State Dept. of Health.
Middletown: Middletown Water Works.

ASSOCIATE

South Norwalk: R. U. V. Co.
Stamford: Payne Dean, Ltd.
Waterbury: American Brass Co., Chase Metal Works.

DELAWARE

Active 5; Total 5

ACTIVE

Wilmington: Butz, Sr., Feeney, Hoopes, Van Trump, Walker.

DISTRICT OF COLUMBIA

Active 11; Total 11

ACTIVE

Washington: Clark, Curtis, Fink, Hardy, Howell, Kay, Lauter, MacQueen, Miller, Phillips, Stevens.

FLORIDA

Active 16; Total 16

ACTIVE

Crescent City: Dissel.
Daytona: Graham, Main.
Jacksonville: Ahern, Bailey, Parker, Simons, Jr., Tyler.
Miami: Hyman.
Orlando: Michaels.
St. Petersburgh: Brown.
Tampa: Jones, McFarland, Squires.
West Palm Beach: Dougherty, Rice.

GEORGIA

Active 11; Corporate 2; Total 13

ACTIVE

Atlanta: Clayton, Grimes, Norcross, Rapp, Wilcox.
Atlanta Station: Mathis.
Augusta: Hunter, Smith, Wingfield.
Columbus: Smalshaf.
Savannah: Valentino.

CORPORATE

Griffin: Light, Water and Sewerage Dept.
West Point: Lanett Cotton Mill.

IDAHO

Active 2; Corporate 1; Total 3

ACTIVE

Idaho Falls: Wilson.
Lewiston: Wagner.

CORPORATE

Boise: Idaho Surveying and Rating Bureau.

GEOGRAPHICAL DISTRIBUTION

ALABAMA

Active 9; Associate 3; Total 12

ACTIVE

Alexander City: Robinson.
Birmingham: Decker, Sweet, Totten.
Mobile: Soost.
Montgomery: Hazlehurst.
Muscle Shoals: Mickle.
Sheffield: Gammon.
Tuscaloosa: Abbott.

ASSOCIATE

Birmingham: American Cast Iron Pipe Co., E. E. Linthicum, Pres., National Cast Iron Pipe Co., McWane Cast Iron Pipe Co.

ARIZONA

Active 3; Corporate 1; Total 4

Ajo: DuMoulin.
Prescott: Shaw.
Tucson: Rider.

CORPORATE

Bisbee: Bisbee-Naco Water Co.

ARKANSAS

Active 3; Corporate 2; Total 5

ACTIVE

Fort Smith: Ward.
Little Rock: Bair, Johnson.

CORPORATE

Hot Springs: Hot Springs Water Co.
Pine Bluff: Pine Bluff Co.

CALIFORNIA

Honorary 1; Active 81; Corporate 8; Associate 7; Total 97

HONORARY

Los Angeles: Mulholland.

ACTIVE

Albany: Costa.
Alhambra: Hilton.
Atascadero: Robinson.
Berkeley: Hyde, Klaus, Langlier, Reinke.
Compton: Parrish.
Dixon: Sedgwick.
Fresno: Jackson.
Hanford: Isaac, Johns.
Hayward: Smalley.
Inglewood: Farmer.
Los Angeles, Barnard, Cates, Finkle, Goudey, Hurlbut, Lawton, Moore, Mudge, Rowe, Slater, Stone, Taylor.
Marysville: Belcher.
Monrovia: Given.
Oakland: Chamberlain, Davis, Gillespie, Hawley, Hunter, Magestadt, Reinhardt, Wilhelm.
Ontario: Roen.
Orlando: Wright.
Pacific Grove: Olmstead.
Pasadena: Allin, Morris.
Sacramento: Jenks, Nickerson, Prugh.
San Diego: Ervast, Lovell.
Salinas: Snell.
San Francisco: Abbott, Andrews, Bragg, Clemens, Elliott, Ellis, Flaa, Graff, Hammerly, Hommon, Hunter, Kempkey, Lee, Luippold, Mars, Martindale, McCaughern, Mendelsohn, O'Shaughnessy, Pracy, Sharon, E. H. Shibley, Kenneth Shibley.
San Jose: Ford.
San Rafael: Burt, Everett, Longland.
Santa Barbara: Trace, Wyant.
Santa Paula: Giacomazzi.
Stockton: Fagg.
Turlock: Brown.
Vacaville: Eldredge.
Watsonville: Kitchen.

CORPORATE

Glendale: Public Service Dept.
Los Angeles: Bureau of Water Works and Supply, Conservative Water Co.
Menlo Park: Bear Gulch Water Co.
Oakland: East Bay Water Co.

CORPORATE

Evansville: Evansville Water Works.
New Albany: Interstate Public Service Co.

ASSOCIATE

Lawrenceburg: A. D. Cook, Inc.
Wabash: Ford Meter Box Co.

IOWA

Active 46; Corporate 4; Associate 1; Total 51

ACTIVE

Ames: Levine, Nichols.
Boone: Ehrhart.
Burlington: Lawlor.
Cedar: Rapids, Bates, Blomquist, Holbrook, Mortensen.
Centerville: Alexander, Stewart.
Clinton: Chase.
Colfax: Donahue.
Council Bluffs: Etnyre, Hansen, Jensen, Maloney, Myrtue.
Davenport: Healey, Henderson.
Des Moines: Corcoran, Denman, Hezzelwood, Higgins, Kastberg, Maffitt, Pederson.
Fort Dodge: Pray.
Fort Madison: Kern.
Harlan: Cox.
Iowa City: Ball, Bartow, Hinman, Waterman.
Jefferson: McGlothlen.
Keokuk: Powers.
Knoxville: Savage.
Marion: Toms.
Marshalltown: Luce.
Mason City: Crofoot.
Muscatine: Molis.
Ottumwa: Brown.
Sioux City: Carlin, Smith.
Waterloo: Hendry, Shoemaker.
Webster City: Currie.

CORPORATE

Creston: Taxpayers Municipal Water Works.
Davenport: Davenport Water Co.
Dubuque: Dubuque City Water Works.
Muscatine: Water Trustees.

ASSOCIATE

Burlington: Murray Iron Works Co.

KANSAS

Active 8; Corporate 2; Total 10

ACTIVE

Atchison: Chisham.
Cummings: Phillips.
Hutchinson: Quillan.
Kansas City: Mangun.
Manhattan: Ulrich.
Topeka: Googins.
Wellington: Mavity.
Wichita: Kelley.

CORPORATE

Emporia: Water Department.
Topeka: City Water and Light Dept.

KENTUCKY

Active 28; Corporate 5; Total 33

ACTIVE

Ashland: Patton.
Carlisle: Clay.
Catlettsburg: Patton.
Covington: Kingsley.
Danville: Prindle, Woolfolk.
Georgetown: Allen.
Lexington: Bell, Bradley, H. R. Cramer, W. S. Cramer, Gillig.
Louisville: Chambers, Horrigan, Long, Lovejoy, McGonigale, Parker, Stover.
Mayfield: Orr.
Maysfield: Cochran.
Mt. Sterling: Blevins.
Newport: Hineman.
Owensboro: Watson.
Paducah: Burnett.
Paris: Mitchell.
Richmond: Dougherty.
Winchester: Attersall.

CORPORATE

Ashland: Ashland Water Commission.
Hopkinsville: Hopkinsville Water Co.
Louisville: Kentucky Utilities Co., State Bd. of Health, Louisville Water Co.

LOUISIANA

Active 6; Corporate 2; Total 8

ACTIVE

New Iberia: Villermin.
New Orleans: G. G. Earl, R. Earl, Eastwood, Fowler.
Shreveport: Amiss.

CORPORATE

Baton Rouge: Baton Rouge Water Works Co.
Lake Charles: Lake Charles Railway Light and Waterworks Co.

MAINE

Active 11; Corporate 1; Total 12

ACTIVE

Augusta: Campbell.
Bangor: Brown, Powell.
Biddeford: Burnie.
Orono: Everett.
Portland: Coburn, Payson, G. F. West, V. F. West.
Rockland: McAlary.
Waterville: Thompson.

CORPORATE

Waterville: Trustees Kennebec Water Dist.

MARYLAND

Active 38; Total 38

Annapolis: Munroe.
Baltimore: Adams, Armstrong, Baylis, Biser, Blohm, Clemmitt, Ellis, Flack, Freeman, Goldstein, Gregory, Hopkins, Keefer, Megraw, Powell, Requardt, Siems, Strohmeyer, Walden, Warren, Wieghardt, Wolf, Wolman.
Cumberland: Fowler.
Frederick: Crum.
Hagerstown: Ferguson, Heard, Voris.
Hyattsville: Develbiss, Hall, Hechmer, Morse, Shaw.
Laurel: Nichols.
Linthicum Heights: Diggs.
Riverdale: Owings.
Salisbury: Dryden.

MASSACHUSETTS

Honorary 1; Active 64; Associate 8; Total 73

HONORARY

Brookline: Fitzgerald.

ACTIVE

Attleboro: Snell.
Boston: Barbour, Barrows, Chase, Clark, Dixon, Fales, Finneran, Flint, Foss, French, Goodnough, Howard, Killam, Marston, McInnes, Metcalf, Sherman, Spiller, Taber, Thorndike, Wentworth, Weston, Wheeler.
Brockton: Kingman.
Brookline: Hale.
Cambridge: Good, G. C. Whipple, M. C. Whipple.
Concord: Robinson.
Danvers: Esty.
Fairhaven: Gidley.
Framingham: Macksey.
Holyoke: Gear, Tighe.
Jamaica Plain: Hough.
Lawrence: Collins, Hale.
Lowell: Reynolds, Safford, Thomas.
Lynn: Newsom.
Mattapan: Gibbons.
Medford: Dwyer.
Methuen: Mahoney.
Milton: Hefferman.
New Bedford: Chase, Drake, Taylor.
Newtonville: Burnham.
Peabody: Emerson.
Springfield: Lochridge.
South Boston: Tilden.
So. Weymouth: Pierce.
Southbridge: Abbott.
Waban: Symonds.
Ware: Merrill.
Watertown: Gilcreas.
Wellesley: Adams.
Wellesley Farms: Barrier.
West Somerville: Lacount.
Williamstown: Mears.
Worcester: Batchelder, Hoy.

ASSOCIATE

Boston: Edson Mfg. Corp.
Florence: Norwood Engineering Co.
Indian Orchard: Chapman Valve Mfg. Co.
Lynn: Lap-Joint Impervious Pipe Co.
Neponset: Coffin Valve Co.
South Boston: Hersey Mfg. Company.
Wakefield: The Lead Lined Iron Pipe Co.
Worcester: Union Water Meter Company.

MICHIGAN

Active 64; Corporate 5; Associate 4; Total 73

ACTIVE

Ann Arbor: Ayres, Decker, Hoad, Holland, Williams.
Bay City: Reid.
Coldwater: McQueen.
Cadillac: Webb.

Detroit: Barton, Bird, Blessed, Collins, Dow, Fenkell, Gerardy, Gould, Grobbel, Hinchman, Hubbell, Jones, Majeske, Mayo, Outzen, Russell, Sosnowski, Stephenson, Sward, Ternes, Wahl, Wallace, Wyckoff.
E. Lansing: Woods.
Flint: Baldwin.
Grand Rapids: Billings, Sperry.
Gross Ile: Mitchell.
Highland Park: Bolton, Whitsit.
Holland: Champion.
Iron Mountain: Cox, Croll.
Jackson: England, Hatch.
Kalamazoo: Libby, Normon.
Lansing: Bulkeley, Hackett, Sheldon.
Ludington: Williams.
Marquette: Johnston.
Monroe: Brisbin.
Mt. Clemens: Keils.
Pontiac: Brower, Lenhardt, Monroe, Shimmel.
Port Huron: Moore, Naumann, Sterosky.
Rochester: Jackson.
Saginaw: Clark, Eymer, Johnson.
Wyandotte: Clark.

CORPORATE

Ann Arbor: Water Works Commission.
Grand Rapids: Dept. of Public Service.
Ironwood: Ironwood Water Department.
Lansing: Michigan State Board of Health.
Saginaw: Saginaw Water Department.

ASSOCIATE

Detroit: Digestive Ferments Company, Michigan Valve and Foundry Co., Sentry Meter Company.
Traverse City: Traverse City Iron Works.

MINNESOTA

Active 41; Associate 2; Corporate 3; Total 46

ACTIVE

Austin: Todd.
Chisholm: Sullivan.
Crookston: Peterson.
Duluth: Brockway, Foster, Reed, Wilson.
Eleventh: Forristel.
Fairmont: Horne.
Faribault: Wilson.
Gilbert: Conner.
Hibbing: Forsberg, McDonald.
Lake City: Howe.
Lakewood: Seligman.
Minneapolis: Bass, Brownell, Crounse, Elsberg, Janzig, Jensen, Johnson, Lykken, McCulloh, Mellen, Raab, Whittaker, Wilbur, Young.
St. Cloud: Seibert.
St. Paul: Childs, Clancy, Crowley Druar, Feist, Kelsey, McDonald, Peter, Routh, Shepard.
Virginia: Pruett.

CORPORATE

Minneapolis: Committee on Water Works, General Inspection Bureau.
Winona: Board of Municipal Work.

ASSOCIATE

Minneapolis: Northern Fire Apparatus Co.
St. Paul: Edward E. Johnson, Inc.

MISSISSIPPI

Active 5; Total 5

ACTIVE

Magnolia: Mentz.
Meridian: Slaughter.
University: Kirkpatrick.
Vicksburg: Worrell.
Winona: Johnson.

MISSOURI

Honorary 1; Active 53; Corporate 2; Associate 2; Total 58

HONORARY

St. Louis: Holman.

ACTIVE

Hannibal: Freiling, Wolfe.
Independence: Gallagher.
Jefferson City: Johnson, Landman, Putnam.
Kansas City: Archer, Bacharach, Benham, Black, Foreman, Gilkison, Haskins, Holbrook, Jewell, King, Learned, Maillard, Maitland, McCall, McClintock, McDonnell, McFarland, Merriman, Mullergren, Pratt, Strang, Veatch, Wesley.
Odessa: Harris.

Rollo: Ueltzen.
St. Louis: Allison, Black, Chivvis, Cutts, Daily, Day, Flad, Fuller, Graf, Henby, Jutz, Monfort, Nelson, Richardson, Skinker, Toensfeldt, Wall, Wilcox.
Sedalia: Andrews.
Springfield: Gray, Pate.
University City: Weir.

CORPORATE

Kansas City: Water Commission.
St. Louis: Illinois Power & Light Corp.

ASSOCIATE

Kansas City: Williams, Electrolytic Chlorine Co.
St. Louis: American Foundry and Mfg. Company.

MONTANA

Active 7; Corporate 1; Total 8

ACTIVE

Billings: Willett.
Bozeman: Cobleigh.
Butte: Carroll.
Helena: Foote.
Kelispell; Lawrence.
Missoula: Christensen.
Roundup: Quinnell.

CORPORATE

Anaconda: Water Works Department.

NEBRASKA

Active 10; Corporate 2; Associate 1; Total 13

ACTIVE

Lincoln: Erickson, Evinger.
Omaha: Barr, Bruce, Knouse, Larmon, Leisen, Prince.
Plattsmouth: Minor.
Wilber: Diller.

CORPORATE

Lincoln: Lincoln City Water and Ltg. Dept.
Omaha: Metropolitan Utilities District.

ASSOCIATE

Grand Island: Kelly Well Company.

NEVADA

Active 2; Corporate 1; Total 3

ACTIVE

Goldfield: Detwiler.
Reno: Campbell.

CORPORATE

Reno: The Truckee River Power Company.

NEW HAMPSHIRE

Active 4; Corporate 1; Total 5

ACTIVE

Concord: Storrs, Howard.
Hanover: Holden.
Manchester: Mendell.

CORPORATE

Nashua: Pennichuck Water Works.

NEW JERSEY

Active 109; Corporate 9; Associate 11; Total 129

ACTIVE

Ampere: Decker, Longley.
Asbury Park: Bartley, White.
Atlantic City: Van Gilder.
Bernardsville: Williamson.
Boonton: Breitzke.
Bound Brook: Downes, Smith.
Bridgeton: Frederick.
Burlington: Caprin, Conard, Buzby.
Camden: Jones, Long, Vosbury.
Cedar Grove: Goslau.
Charlotteburg: Craig.
Clifton: Mahoney, Scacciaferro.
Collingswood: Borden.
East Orange: Halpin, Klein, Snyder, Roper.
Elizabeth: Booth, Radcliffe, Townley.
Franklin: Jenkins.
Glen Ridge: Brooks.
Haddon Heights: Smith.
Harrison: Matte.
Haskell: Holdredge.
Hoboken: Anderson.
Jersey City: Cleflin, Corbin, Mauzy, McEvoy, Spencer, VanKeuren.
Little Falls: Green.
Lodi: McClellan.
Maplewood: Wigley.
Merchantville: Rudderow.
Middlebush: Mallalieu.
Montclair: Knox.

Moorestown: Bishop.
Newark: Baldwin, Bank, Foulks, Kappler, Judson, Mowry, Mueller, Orchard, A. H. Pratt, G. H. Pratt, Rosentreter, Sanzenbacher, Scherer, Scholz, Sherman, Sherrerd, Woolley.
New Brunswick: Atkinson, Jones, Lendall, Morris.
Orange: Luthy.
Passaic: Hopper.
Patterson: Cook, Cuddeback, Edwards, Harder, King, Ryle, Towle.
Perth Amboy: Mason.
Plainfield: Analyst.
Pleasantville: Herr, Trumbore.
Princeton: Eldridge.
Ridgewood: Carr, Phelps, Simonds.
Riverside: Port, Buck.
Roselle Park: Crane.
Rutherford: Tygert.
Sayreville: Weber.
Short Hills: Kohout.
S. Orange: Nolan.
Spring Lake: Besselievre.
Summit: Bassett, Cadman, Kimball.
Trenton: Boyle, Brooks, Croft, Thompson.
Upper Montclair: Goodell.
Weekawken: French, Miller, Parker, Talbot.
West Orange: Fritz, Glannan.
Westfield: Brush.
Woodbridge: Mundy.

CORPORATE

Camden: The Stockton Water Co.
Dover: Dover Water Commissioners.
East Orange: Board of Water Commissioners.
Glen Ridge: Glen Ridge Water Dept.
Millville: Millville Water Company.
Mount Holly: The Mount Holly Water Company.
Totowa: Borough of Totowa.
Trenton: N. J. Dept. Conservation and Development, Trenton Water Works.

ASSOCIATE

Ampere: Lock Joint Pipe Company.
Bayonne: The Babcock and Wilcox Co.
East Orange: The A. P. Smith Mfg. Co.
Jersey City: Joseph Dixon Crucible Company, Voorhees Rubber Mfg. Co.
Newark: Gamon Meter Company, Newark Brass Works, Wallace and Tiernan Co. Inc.
Paterson: American Zeolite Corp.
Pleasantville: Van Gilder Water Meter Company.
Trenton: De Laval Steam Turbine Company.

NEW MEXICO

Active 1; Corporate 3; Total 4

ACTIVE

Cimarron: Alpers.

CORPORATE

Carlsbad: The Public Utilities Company.
Deming: Deming Water Department.
Santa Fe: Santa Fe Water & Light Co.

NEW YORK

Honorary 3; Active 275; Corporate 24; Associate 50; Total 352

HONORARY

New York: Herschel, Purdy.
Troy: Diven, Sr.

ACTIVE

Albany: Cox, Holmquist, Horton, Mullikin, Prior, Schwartz, Suter, Wachter, Wells, Wheeler, Willcomb.
Amsterdam: Dwyer.
Avon: Clark.
Binghampton: Gitchell.
Briarcliff Manor: Manahan.
Brooklyn: Aeryns, Armstrong, Bleistein, Cunningham, Dowd, Flannery, Hale, Hendrick, Kief, Lott, Metcalf, Moore, Vertefeuille, Woolnough.
Buffalo: Ames, Andrews, Byole, Bartram, Charles K. Bassett, George B. Bassett, Chambers, Diehl, Fitzgerald, Grotz, Huy, Nussbaumer, Parsons, Spire, Wagner.
Canandaigua: Douglas.
Cedarhurst, L. I: Lord.
Corning: Drake.
Cortland: Maxon.
Croton-on-Hudson: Barnes.
East Rochester: Babcock.
Elmira: Jones.
Elmsford: O'Conner.

Far Rockaway: L. I. Bettes, Durland, Stearns.
Flushing: Laase.
Geneseo: Meeker.
Gloversville: Orr.
Grand Gorge: Gausmann, Honness.
Hempstead: Marshall.
Herkimer: Clark.
Hudson Falls: Reid.
Ilion: Trimble.
Ithaca: Chamot, Georgia, Seery.
Jamestown: Swanson.
Katonah: Coffin.
Kingston: Harrison.
Little Falls: Feeter.
Long Island City: Ankener, Donnelly.
Lynbrook, L. I.: E. W. Clark, Sherman.
Lyons: Zimmerlin.
Mamaroneck: Duffy.
Manhasset: Hoag.
Medina: Howell.
Merrick: Spear.
Mineola: Bowne.
Mt. Kisco: Sawin.
Mt. Vernon: Havill, Wolbert.
Newark: Scarth.
New Brighton: Haley.
Newburgh: Eglof, Gilcrist.
New Rochelle: Applebaum, Hoffmaster, Kemble, Reynolds.
Queens: Keogh.
New York: Adams, Baker, Henry DeF. Baldwin, Robt. T. Baldwin, Ballou, Barnes, Barns, Berry, Beyer, Biggs, Blanchard, Blossom, Bogert, Booth, Bowe, Brush, Charles H. Bull, Irving C. Bull, Buttenheim, Case, Chase, Cleveland, Cleverdon, Cole, Coulter, Culyer, Dennett, Diven, Jr., Donaldson, Dorsey, Duggan, Dunham, Dunlap, Everett, Ewry, Ferguson, Finlay, Jr., Flinn, Folwell, Freer, Fuertes, Fuller, Geehan, Gould, Griffiths, Hansen, Harding, Harding, Jr., Hazen, Hill, Jr., Hoag, Hoagland, Hodgman, Hogan, Howland, Hutson, Jackson, Jacobs, Johnson, Johnstone, Jones, Kienle, Kivell, Kriegsheim, Ledden, Loney, Manahan, McKay, Merriman, Meyerherm, Milholland, Moulton, Nelson, Niesley, Patitz, Pease, Pincus, Pirnie, Potter, Potts, Provost, Jr., Rice, Rodman, Sanborn, Scott, Merritt H. Smith, J. Waldo Smith, Stearns, Stevens, Stewart, Sullivan, Tainter, Tribus, Tuttle, Vermeule, Watson, Watt, Wells, Wiggin, Williamson, Wolfe, Wood, Wyckoff.
Niagara Falls: Dignan, Moyer, Perry, Reisweber, Suitor.
North Tarrytown: Helling.
North Tonawanda: Batt.
Norwich: Ames.
Ogdensburg: Lord.
Oneida: White.
Ossining: Bedell.
McCaffrey: McCaffrey.
Peekskill: Ahearn, Clark, Coe, Lockwood.
Prattsville: Fifield, Hayes, Hunter.
Rensselaer: Claflin.
Rochester: Baker, Geo. H. Bliven, M. Harvey Bliven, Cripps, Dewey, Fisher, Hopkins, Lewis, Little, Matthews, Story, Wells.
Scarsdale: Gerhard, Henshaw.
Schenectady: Clinton, Devendorf, Erickson.
Schuylerville: Greenalch.
Slingerlands: Slingerland.
Sodus: Starbird.
South Nyack: Kendall.
Southampton: Van Brunt.
Stapleton: Volkhardt.
Syracuse: Booth, Daw, Hodgkins, Keating, Kelly, Palmer, VanGorder.
Troy: Caird, Caldwell, Clifton, Knickerbacker, Mason, Stark.
Utica: Beck, Hodges, Hopkins, Miles, Reagan, Jr.
Valhalla: Bampton.
Voorheesville: Horton.
Wappingers Falls: Whitehouse.
Waterloo: Stewart.
Watertown: Ackerman, Field.
Watervliet: Halpin.
Wellsville: Allen, Rowe.
White Plains: Mapes, Paddock.
Woodhaven: Luce.
Yonkers: Buhrendorf, Foley, Henderson, Trobridge, Wegman.

CORPORATE

Auburn: Water Dept.
Buffalo: Bureau of Water, Western New York Water Co.
Corning: Water Works.
Elmhurst, L.I.: Citizens Water Supply Co.
Elmira: Water Board.
Glens Falls: Board of Water Commissioners.
Ilion: Board of Water Commissioners.

Kenwood: Sherrill-Kenwood Water Commission.
Lockport: Board of Water Commissioners.
Maspeth, L. I.: Urban Water Supply Co.
Massena: St. Lawrence Water Co.
New York: American Water Works and Electric Co., Federal Light and Traction Co. Vinton-Roanoke Water Co.
Oswego: Department of Water.
Owego: Water Works.
Point Pleasant: Sea Breeze and Vicinity Water Commission.
Poughkeepsie: Board of Public Works.
Rome: Bureau of Water.
Syracuse: Bureau of Water.
Troy: Bureau of Water.
Watertown: Water Works.
White Plains: Department of Public Works.

ASSOCIATE

Baldwinsville: Morris Machine Works.
Brooklyn: Federal Meter Co., Thomson Meter Co.
Buffalo: Buffalo Meter Co., W. P. Taylor Co.
Cohoes: Cohoes Rolling Mill Co.
Elmira: Kennedy Valve Mfg. Co., A. Wyckoff and Son Co.
Newburgh: Coldwell-Wilcox Co.
New York: Ambursen Construction Co., Inc., American City, Arnold, Hoffman and Co., Inc., Central Foundry Co., Conover and Phillips, Copper and Brass Research Association, East Jersey Pipe Co., Electro Bleaching Gas Co., Engineering News-Record, Elliott-Fisher Co., Fire and Water Engineering, Hooker Electrochemical Co., John Fox and Co., T. A. Gillespie Co., Ingersoll-Rand Co., Kalbfleisch Corp., Kraus Research Laboratories, Inc., Mathieson Alkali Works, Inc., National Meter Co., National Water Main Cleaning Co., Neptune Meter Co., Parsons, Klapp, Brinckerhoff and Douglas, Permutit Co., Pitometer Co., Public Works, Sanitation Corp., S. E. T. Valve and Hydrant Co., Sims Pump Valve Co., United Lead Co., Warren Foundry and Pipe Co., Water Works Equipment Co., J. G. White Engineering Corp., Worthington Pump and Machinery Corp.
Peekskill: Fleischmann Co.
Schenectady: Lee F. Adams, General Electric Co.
Troy: W. and L. E. Gurley, Ludlow Valve Mfg. Co., Rensselaer Valve Co., Ross Valve Mfg. Co., Inc.
Waterford: Eddy Valve Co.
Watertown: Glenn R. Shriver, Gen. Mgr., John Weekes and Son Co.

NORTH CAROLINA

Active 87; Associate 1; Total 88

ACTIVE

Albermarle: Widenhouse.
Ashville: Hall, Hollingsworth.
Bessemer City: White.
Chapel Hill: Bennett, Drane, Saville.
Charlotte: Davis, Booker, Heyward, Marshall, McConnell, Mees, Moulton, Myers, Neville, Vest.
Concord: Fisher.
Cramerton: Sullivan.
Durham: Davis, Michie, Piatt, Stratton, Suggs, White, Williams.
Eagle Springs: Maurice.
Farmville: McAdams.
Fayetteville: Shell.
Franklinton: Jenkins.
Fremont: Benton.
Gastonia: Struthers, Rhyne.
Goldsboro: Grantham, Toler, Williams.
Greensboro: Boyles, Lewis, Smedberg, True.
Henderson: Bridgers.
Hendersonville: Wright.
La Grange: DeCamp.
Leaksville: Moore, Trogdon.
Lexington: Jones.
Lillington: Dixon.
Mooresville: Fields.
Mount Airy: Absher, Whitlock.
Mount Holly: Patterson.
New Bern: Godfroy.
Oxford: Ward.
Pinehurst: Pender.
Raleigh: Bain, Baity, Bandy, Brockwell, Catlett, Jones, Kellogg, McLeod, Miller, Olsen, Welsh.
Rock Mount: Large, Lyon.
Salisbury: Craig, Rodgers.
Saluda: Newton.
Smithfield: Wilson.
Statesville: Cochran, Worth.
Tarboro: Martin.
Tryon: Beebe.

Wake Forest: McKaughan.
Waynesville: Logan.
Wilmington: Bishop, Maffitt, Norcom, Sweeney.
Wilson: Gladding, Turner, Whitley.
Winsor: Lassiter.
Winston-Salem: Ludlow.
Zebulon: Bizzell.

ASSOCIATE

Charlotte: The Grinnell Co., Inc.

NORTH DAKOTA

Active 3; Honorary 1; Total 4

HONORARY

Bismarck: Caulfield.

ACTIVE

Bismarck: Atkinson.
Fargo: Jacobsen.
Minot: Thomas.

OHIO

Active 74; Corporate 11; Associate 8; Total 93

ACTIVE

Akron: Hibbs, Rhynus, Tolles.
California: Bahlman.
Cambridge: Rollins.
Canton: McClaskey, Ohliger.
Cincinnati: Boeh, Hill, Miller, Rudd, Streeter.
Cleveland: Beardsley, Farrell, Flower, Frazier, Gascoigne, Jaeger, Levy, Marshall, Martin, Morrow, Perkins, Quayle, Ruggles, Sheal, Siedle, Jones.
Columbus: Bradbury, Burgess, Dittoe, Eno, Groeniger, C. P. Hoover, C. B. Hoover, Kimberly, Lawrence, Martin, McAlpine, Walker, Waring.
Dayton: Morehouse, Wight.
Defiance: Campion.
Dennison: Romig.
East Liverpool: Rupp.
Elyira: Beck.
Kent: Gettrust.
Lakewood: Ellms, Kunzelman.
Lima: Evans.
Lorain: Brown, Pauly.
Medina: Fretter.
Salem: Morlan.
Shelby: Bricker.
Steubenville: Scott.
Tiffin: Wetter.
Toledo: Brown, Champe, Clark, Furman, Jones, Schoonmaker, Roberts, Sherman, Sleeper.
Warren: Inman, O'Connor.
Washington: O'Neall.
Xenia: Zell.
Youngstown: Russell, Van Arnum, Wilson.

CORPORATE

Ashtabula: The Ashtabula Water Supply Company.
Columbus: Ohio Inspection Bureau.
Lorain: Lorain Water Works.
Massillon: Massillon Water Supply Company.
Marion: The Marion Water Company.
Middleport: The Meigs Water Company.
Sandusky: Filtration Plant.
Toronto: Board of Public Affairs.
Wilmington: The Dayton Power and Light Co.
Youngstown: The Mahoning Valley Water Company, Youngstown City Water Dept.

ASSOCIATE

Cincinnati: Bourbon Copper and Brass Works Co., The John H. McGowan Co.
Cleveland: The Bowler Foundry Company, the Farnan Brass Works Co., Glauber Brass Mfg. Company, United Brass Mfg. Company.
Findlay: Buckeye Traction Ditcher Co.
Toledo: The National Supply Company.

OKLAHOMA

Active 7; Total 7

ACTIVE

Alva: Nighswonger.
Chickasha: McBurnett.
Okla. City: Bretz, Spaulding.
Ponca City: Crow.
Tulsa: Holway, Wardle.

OREGON

Active 6; Corporate 1; Total 7

ACTIVE

Hillsboro: Gates.
Marshfield: Corey.
Portland: Ehle, Koon, Randlett, Willard.

CORPORATE

Portland: Dept. of Public Utilities.

PENNSYLVANIA

Active 159; Corporate 14; Associate 26; Total 199

ACTIVE

Allentown: Schnabel.
Altoona: Campbell.
Ambler: Hibschman.
Aspinwall: Drake.
Berwick: Hicks.
Bethlemen: Fox, Knerr, Shipman.
Bristol: Roberts.
Brookville: Sayer.
Carlisle: Faller.
Castasauqua: Muser.
Chambersburg: McGrath.
Chester: Boynton, Calhoun, Lamey.
Chinchilla: Salisbury.
Clearfield: Hess, Nevling, Young.
Columbia: Meyers.
Cooperstown: Crawford.
Corry: Brown.
Downingtown: Wagner.
Easton: Rader.
East Pittsburgh: Holmes.
Erie: Dunwoody, Gensheimer.
Ford City: Wintgens.
Germantown: Corin.
Glenside: Goentner.
Greensburg: Smith, Spencer.
Harrisburg: Avery, Barrick, Craig, Daniels, Freeburn, Gannett, Glace, Hassler, Lamb, Mark, Moses, Scheffer, Stevenson, Wertz.
Hazleton: McGeehin.
Jersey Shore: Kinter.
Johnstown: Crichton, Kunkle, Watkins.
Kingston: Matter.
Lancaster: Goodell, Ruth, Will.
Lehighton: West.
Lemoyne: Young.
McKeesport: Trax.
Meadville: Ellsworth.
Monongahela: Nutt.
Norristown: Russell.
North East: Leet.
Oakmont: Newman.
Philadelphia: Barlett, Bean, Birkinbine, Blew, Boardman, Cady, Doten, Dougherty, Dunlap, Durst, Easby, Jr., Ely, Emerson, Jr., Gushee, Hasskarl, Haydock, Jenne, Kneen, Lawrence, Ledoux, Levering, Lightfoot, Jr., McCaleb, McCrudden, Nichols, Potteiger, Riebell, Russell, Saunders, Schaut, Siddons, Stone, Streander, Suttle, Swaab, Thomas, Tolson, Trautwine, Jr., Van Loan, Walker, Wood.
Pittsburgh: Bankson, Baton, Brennan, Chester, Douglass, Foote, Harshbarger, Hopkins, Hudson, Hutton, Knowles, Laboon, Lanpher, Leopold, Lines, Lynn, Mansfield, Mellon, Rice, Simpson, Speller, Taylor, Weidlein, Wilcox.
Pottsville: Beisel.
Reading: Felix, Filbert, Nuebling, Reber.
Sayre: West, Wright.
Scranton: Cox, Nebelung, Taylor.
Shamokin: Haupt, McWilliams.
Shenandoah: Rassier.
Shrewsbury: Giesey.
State College: Sackett, Walker.
Steelton: Litch.
Sunbury: Rohrbach.
Swarthmore: Alleman, Fuller.
Vandergrift: Horn.
Warren: Mitchell.
Wayne: Pugh.
Wilkes Barre: Vail, Wintermute.
Wilkinsburg: Fox, Nawley.
Williamsport: Keliher, Wilhelm.
York: Kable.

CORPORATE

Allentown: Allentown Water Dept.
Easton: Northampton Consolidated Water Company.
Erie: Commrs. Water Works in the City of Erie.
Lewistown: Lewistown-Reedsville Water Co.
Mount Carmel: Mount Carmel Water Company.
Scranton: Scranton Gas and Water Co.
Sharon: Sharon Water Works Company.
Shenandoah: Commissioners of Water Works.
Uniontown: Trotter Water Co.
Verona: The Suburban Water Co.
West Chester: Borough of West Chester.
West Newton: West Newton Water Co.
Williamsport: Eagles Mere Water Company, Williamsport Water Co.

ASSOCIATE

Berwick: Multiplex Mfg. Company.
Bradford: S. R. Dresser Mfg. Company.
Emaus: Donaldson Iron Company.
Erie: Hays Mfg. Company.

Philadelphia: American Manganese Bronze Co., The American Pipe and Constn. Co., American Water Softener Company, Bayard, E. I. duPont de Nemours and Company, H. S. B. W. Cochrane Corporation, The Leadite Company, Inc., The Pennsylvania Salt Mfg. Company, Roberts Filter Mfg. Company, Scofield Engineering Company, Simplex Valve and Meter Company, United States Cast Iron Pipe and Foundry Company, R. D. Wood and Company.
Pittsburgh: A. M. Byers Co., Dravo-Doyle Co., National Tube Company, Pittsburgh Des-Moines Steel, Pittsburgh Meter Company, Pittsburgh Testing Laboratory, Laboratory, Riter-Conley Company.
Scranton: Acker.
Williamsport: The Darling Valve and and Mfg. Company.

RHODE ISLAND

Active 5; Associate 1; Total 6

ACTIVE

Bristol: Jones.
Providence: Bugbee, Marsh, Richardson, Winsor.

ASSOCIATE

Providence: Builders Iron Foundry.

SOUTH CAROLINA

Active 5; Corporate 1; Total 6

ACTIVE

Charleston: Gibson.
Cheraw: Smith.
Columbis: Filby.
Greenville: Perry.
Spartanburg: Simme.

CORPORATE

Charleston: Commissioners of Public Works.

SOUTH DAKOTA

Active 5; Total 5

ACTIVE

Huron: Hays.
Redfield: Olding.
Sioux Falls: Connor.
Vermillion: Hunter.
Waubay: Wieters.

TENNESSEE

Active 17; Corporate 4; Associate 3; Total 24

ACTIVE

Chattanooga: Lofton, Porzelius.
Fountain City: Murphy.
Greenville: McAmis.
Knoxville: Switzer.
Memphis: Allen, Barnett, Cunningham, Davis, Mantel, Mather, Stratton, Stromquist.
Nashville: Fullerton, Harrub, Holman, Reyer.

CORPORATE

Columbia: Columbia Water and Light Company
Kingsport: Kingsport Utilities, Inc.
Knoxville: Knoxville Water Department.
Memphis: Board of Water Commissioners.

ASSOCIATE

Chattanooga: Columbian Iron Works.
Knoxville: W. J. Savage Company.
Memphis: Layne and Bowler Company.

TEXAS

Active 13; Corporate 1; Total 14

ACTIVE

Austin: Avery, Norris.
Beaumont: Bernhagen.
College Station: Bird.
Dallas: Elrod, Morey, Jr., O'Neill, Rosenthal.
El Paso: Tarbett.
Ft. Worth: Hawley, Mahlie.
San Antonio: Bartlett, Harding.

CORPORATE

Waco: Waco Water Works.

UTAH

Active 3; Corporate 1; Total 4

ACTIVE

Brigham City: Roskelley.
Salt Lake City: Bedell, Painter.

CORPORATE

Salt Lake City: Salt Lake City Water Dept.

VERMONT

Active 2; Total 2

ACTIVE

Burlington: Charron, Moat.

VIRGINIA

Active 32; Corporate 2; Associate 2; Total 36

ACTIVE

Alexandria: Lambert.
Charlottesville: Williamson.
City Point: Hallers.
Covington: Barnett.
Danville: Talbott.
East Falls Church: Frick.
Fredericksbury: Houston, Jr.
Hampton: Engle.
Lynchburg: Perrow, Wagner.
Newport News: Dugger, Livezey, Manville, Randolph, Thom.
Norfolk: Ball, Bliven, Herbert, Watkins.
Petersburg: Bunting, Cranch.
Portsmouth: Davis.
Richmond: Baldwin, Bardwell, Claiborne, Davis, Enslow, Howes, Messer, Trafford.
Roanoke: Moore.
Winchester: Dettra.

CORPORATE

Alexandria: Alexandria Water Company.
Hopewell: The Industrial Serv. Corp. of Va.

ASSOCIATE

Lynchburg: The Glamorgan Pipe and Foundry Company, Lynchburg Foundry Co.

WASHINGTON

Active 9; Corporate 2; Total 11

ACTIVE

Everett: Klapp.
Hoquiam: Heermans.
Seattle: Botten, Jacobs.
Spokane: Harding, Murray.
Tacoma: Kuniak, Roberts.
Vancouver: Clarke.

CORPORATE

Raymond: Water Department.
Spokane: Superintendent Water Division.

WEST VIRGINIA

Active 24; Corporate 4; Total 28

ACTIVE

Bluefield: McCarthy, Ridley.
Charleston: Dodd, Ferguson, Musser, Tisdale, Warrick.
Chester: Young.
Clarksburg: Bates, Highland.
Elkins: Tyler.
Fairmont: Jones, Morris.
Huntington: Berberick, Watt.
Martinsburg: Fetzer.
Moundsville: Hetzer.
Point Pleasant: Thomas.
Princeton: Day.
Shinnston: Riffee.
St. Albans: Campbell.
Welch: Rouse.
Weston: Blair, Jr.
Wheeling: Butts.

CORPORATE

Charleston: West Va. Water and Elec. Co.
Dunbar: Dunbar Water Company.
Keyser: City of Keyser.
Morgantown: West Virginia Utilities Company.

WISCONSIN

Honorary 1; Active 37; Corporate 5; Associate 3; Total 46

HONORARY

Milwaukee: Benzenberg.

ACTIVE

Antigo: Jackson.
Beloit: Lyons.
Clintonville: Lyon.
Eau Claire: Brown.
Et. Atkinson: Leonard.
Janesville: Griffey.
Kenosha: Hurtgen.
Madison: Baker, Corp, Kirchoffer, Mead, Miller, Peirce, Smith.
Manitowoc: Schroeder.
Marshfield: Marvin.
Menasha: Kuester.
Milwaukee: Bohmann, Daniel, Engh, Gruetzmacher, Hatton, Leach, Murphy, Sando, Schwada.

Neenah: Marty.
Oshkosh: Maddock.
Racine: McElroy.
Sheboygan: Donohue.
Stoughton: Snyder.
Superior: Lounsbury, Winslow.
Waukeshaw: Hayford.
Wauwatosa: Hebbring.
West Allis: Prochnow.
Wisconsin Rapids: Gross.

CORPORATE

Appleton: Appleton Water Commission.
Delavan: Delavan Water Commission.
Fond du Lac: City Water Dept.
Green Bay: Green Bay Water Dept.
Sheboygan: Board of Water Commissioners.

ASSOCIATE

Milwaukee: Allis-Chalmers Mfg. Company, Badger Meter Mfg. Co., Chain Belt Compnay.

WYOMING

Active 1; Total 1

ACTIVE

Rock Springs: Bell.

CANADA

Active 109; Corporate 14; Associate 7; Total 130

ACTIVE

Brampton: Early.
Brandon: Shaw.
Brantford: Frank, Wilson.
Brockville: Farquharson.
Dandas: Wright.
Edmonton: Owens, Turner.
Elmira: Bowman.
Galt: Cowan, Fairchild.
Grimsby: Bromley.
Hamilton: McFaul.
Ingersol: Hall.
Kincardine: Foerster.
Kitchener: Pequegnat.
Lindsay: Hammond.
London: Hodkinson.
Winnipeg: Hooper.
Montreal: Cousineau, Dorrance, Farmer, Field, Hale, Hunter, Hutchinson, Lafreniere, Laurie, Lea, Le Sage, Leslie McCrady, Meadows, Montabone, Perry, Pitcher, Plamondon, Ross, Scofield, Surveyer, Ward.
New Toronto: Thomas.
Niagara Falls: Collins, Ferris, Green, Warder.
Orangeville: Marshall.
Orillia: Starr.
Ottawa: MacDonald, J. B. McRae, W. P. McRae.
Perth: Smith.
Petersborough: Dobbin, Hunt.
MacDonald College: Stephen.
Quebec: Casgrain, Tremblay.
Regina: Farrell.
St. Catharines: Milne.
St. Stephen: Laflin.
St. Thomas: Miller.
Sarnia: Hall.
Shawinigan Falls: Vauquette.
Sherbrooke: McKeown.
Smith Falls: Hayes.
Stratford: Myers.
Strathroy: Smithrim.
Temiskaming: Grimer.
Toronto: Allen, Angus, Benschoten, Berry, Chipman, Dallyn, Fellows, Gaby, Gore, Hannan, Harris, Harrison, Heath, Howard, Mitchell, Proctor, Redfern, Routledge, Rust, Salmond, Sanderson, Storrie, Thompson, Walker, Wynne-Roberts.
Vancouver: Brakenridge, Dowling.
Victoria: Blair, Cleveland.
Walkerville: Brown.
Waterloo: Schiedel.
Welland: Milo.
Weston: Peirson.
Windsor: Code, Hanna, Keith, Kellner.
Winnipeg: Finlayson, Scott, Stainton.
Woodstock: Archibald.

CORPORATE

Brampton: Brampton Water Commission.
Brantford: Brantford Water Commissioners.
Chatham: Board of Water Commissioners.
Guelph: Hastings.
Kitchener: Kitchener Water Commission.
London: Public Utilities Commission.
Petersborough: Dobbin, Petersborough Utilities Commission.
Regina: Water Works Department.

St. Mary: Board of Water Light and Heat Comn.
St. Thomas: St. Thomas Water Commissioners.
Welland: Board of Water Commission.
Whitby: The Public Utility Commission.
Windsor: The Water Commissioners.

ASSOCIATE

Toronto: The Canadian Engineer, Drummond, McCall and Co., Ltd., Hugh C. MacLean Publications, Ltd., Nat'l Iron Corp., Neptune Meter Co.
Montreal: Francis Hankin and Co., Ltd., Jenkins Bros., Limited.

FOREIGN

Active 58; Corporate 5; Honorary 2; Total 65

ACTIVE

ARGENTINE REPUBLIC

Bahia Blanca: Anthony.
Buenos Aires: Gunning, Lasso, Paitovi.
Rosario de Santa Fe: Buchanan, Moir.
San Nicolas: Hudson.

AUSTRALIA

Melbourne: Futteridge, Neylon, Ritchie, Sutherland.
Newcastle: Ewing.
Sydney: Blain.
Victoria: Upton.

CANAL ZONE

Ancon: Bunker, Nolte.
Cristobal: Dunn.

CENTRAL AMERICA

San Salvador: Klein.

CHILE

Santiago: Lira.

CHINA

Shanghai: Gaunt, Pearson.
Tientsin: Clark.

COLOMBIA

Barranquilla: Stringfellow.
Bogota: Fauco.

CUBA

Camaguey: Pradas.
Guantanamo: Salcinez.
Habana: Montoulieu.
Havana: Cosculluela, Martinez.

CZECHOSLOVAKIA

Brandys Labe: Zehr.

DENMARK

Copenhagen: Jarvis.

ENGLAND

Birmingham: Dixon.
Buxton: Race.
London: Cameron, Howland.
Northwich: Munro.

FRANCE

Nancy: Cavallier.

GERMANY

Breslau: Meinecke.

HOLLAND

Utrecht: Massink, Meerburg.

INDIA

Bombay: Prokofieff.

JAPAN

Osaka: Takayama, Sawai.
Tokio: Nishioeda, Inoue, Kayanoki, Iwasaki.

MEXICO

Tampico: McIntosh.

PANAMA

Gatun Canal Zone: Beers.

PHILIPPINES

Manila: Gideon.

POLAND

Warsaw: Nowakowski.

PORTO RICO

San Juan: Canals.

QUEENSLAND

Brisbane: Peart.

SCOTLAND

Aberdeen: Mitchell, Spencer.
Ayr: Ball.
Iverness: Grant.

SWEDEN

Stockholm: Greyerz.

STRAITS SETTLEMENTS

Singapore: Tomlinson.

TERRITORY OF HAWAII

Honolulu: Ellis, Tay, Wall.

WEST AUSTRALIA

Perth: Lawson.

CORPORATE

AUSTRALIA

Sydney: Metropolitan Board of Water.

HOLLAND

Utrecht: Utrechtsche Waterleiding-Maatschappij.

NEW MEXICO

East Las Vegas: Agua Pura Company.

SWEDEN

Malmo: Byggnadskontor.

TERRITORY OF HAWAII

Oahu: Wahiawa Water Company, Ltd.

HONORARY

ENGLAND

London: Houston.

JAPAN

Tokyo: Nakajima.

SUMMARY BY STATES

	Active	*Corporate*	*Associate*	*Honorary*	*Total*
Alabama	9		3		12
Arizona	3	1			4
Arkansas	3	2			5
California	81	8	7	1	97
Colorado	9		1		10
Connecticut	22	3	4		29
Delaware	5				5
Dist. of Col	11				11
Florida	16				16
Georgia	11	2			13
Idaho	2	1			3
Illinois	112	6	18	1	137
Indiana	32	2	2		36
Iowa	46	4	1		51
Kansas	8	2			10
Kentucky	28	5			33
Lousiana	6	2			8
Maine	11	1			12
Maryland	38				38
Massachusetts	64		8	1	73
Michigan	64	5	4		73
Minnesota	41	3	2		46
Mississippi	5				5
Missouri	53	2	2	1	58
Montana	7	1			8
Nebraska	10	2	1		13
Nevada	2	1			3
New Hampshire	4	1			5
New Jersey	109	9	11		129
New Mexico	1	3			4
New York	275	24	50	3	352
North Carolina	87		1		88
North Dakota	3			1	4
Ohio	74	11	8		93
Oklahoma	7				7
Oregon	6	1			7
Pennsylvania	159	14	26		199
Rhode Island	5		1		6
South Carolina	5	1			6
South Dakota	5				5
Tennessee	17	4	3		24
Texas	13	1			14
Utah	3	1			4
Vermont	2				2
Virginia	32	2	2		36
Washington	9	2			11
West Virginia	24	4			28
Wisconsin	37	5	3	1	46
Wyoming	1				1
Canada	109	14	7		130
Foreign	63	5		2	70
	1749	155	165	11	2080
Last report	1532	131	160	8	1831
Gain since October 1, 1923	217	24	5	3	249

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 12 NOVEMBER, 1924 No. 3

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JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 12 NOVEMBER, 1924 No. 3

MANUAL OF AMERICAN WATER WORKS PRACTICE

The *Manual of American Water Works Practice* is a most ambitious project to be undertaken by an organization like the American Water Works Association. To summarize in a few hundred pages the essential facts upon which the business of water supply rests and to outline current practice in administering those branches of the business peculiar to it, call for the coöperation of many individuals in order that the book shall be unbiased, comprehensive, well-balanced and authoritative.

Fortunately we are not without a notably successful precedent in this undertaking. Some twenty years ago a manual of standard railway engineering practice was started by the American Railway Engineering Association. It has been revised many times since the first edition appeared. There are many standing committees engaged in keeping this volume closely yet conservatively up to date, with the result that it is one of the very few books accepted by federal courts as authorities. We have taken advantage of the experience of our sister association in blocking out the plans for the first edition of our own manual.

The work will be done by group effort. Some of our committees have provided, or will soon do so, a part of the information suitable, when condensed, for the Manual. The chairmen of these committees will, of course, be responsible for reviewing with their associate committeemen the specific features of water works practice assigned to them. However, there are many subjects outside the restricted fields of these committees which must be summarized for

our book. Many of these subjects we have asked individuals to epitomize for us, with authority to associate other members with them in their tasks and to ask for information outside as well as within our membership. Still other subjects are of a practical nature and these are being developed by using questionnaires, supplemented in some cases, we hope, by discussions at meetings of our local sections and National divisions. Already we have been much surprised and gratified by the value of the early results of this branch of our undertaking.

The book is being developed according to the following general plan, which does not, however, indicate the sequence in which the topics will be printed. We bespeak for the committees and members named as responsible for providing information on the topics assigned to them, the prompt and hearty coöperation of those to whom they apply for information and assistance.

Abel Wolman,
Editor.

Malcolm Pirnie,
Secretary.

George W. Fuller,
Frank A. Barbour,
W. S. Cramer,
W. W. DeBerard,
Edward E. Wall
Council on Standardization

Tentative outline of topics for inclusion in Manual of Water Works Practice, American Water Works Association and assignments for development of material

Topic Number

1 Outline of the water works industry, with brief historical and statistical review of its development. *M. N. Baker.*

2 Constituents of water with outline of objectionable limits of various substances and of their relation to practical problems. *A. M. Buswell and S. T. Powell.*

3 General theory of disease and longevity in water of typhoid fever and other disease germs. *W. H. Frost.*

4 Typhoid fever statistics with explanatory statement as to their local significance. *S. M. Van Loan.*

5 Water quality standards. *A. Wolman.*

6 Jurisdiction of health authorities over water supplies. *A. J. McLaughlin.*

7 Ground water supplies, their selection and pumping from the ground. *L. A. Smith.*

8 Recent pumping station practice. *L. A. Day (As Chairman of Committee No. 7).*

9 Allocation of streams for water supplies of various cities. *L. P. Wood.*

10 Summary of runoff data for representative streams and relation between watershed yields and required storage. *A. Hazen.*

11 Summary of flood flow data of representative streams in relation to spillways. *Weston Fuller.*

12 Practice as to watershed protection. *H. E. Moses (As Chairman of Committee No. 5), T. Merriman, C. A. Holmquist, R. Messer, T. Saville, F. M. Randlett.*

13 Industrial wastes in relation to water supplies. *A. L. Fales (As Chairman of Committee No. 6).*

14 Findings of International Joint Commission in relation to pollution of boundary waters between the U. S. and Canada. *H. P. Eddy.*

15 Customs as to compensation in money and compensation in kind for water diversion. *Chas. T. Main and Wm. Gore.*

16 Relative merits of supply pipes of different kinds. *D. H. Maury.*

17 Nomenclature and physical standards of distribution systems. *G. G. Dixon (As Chairman of Committee No. 8).*

18 Modern views as to service reservoirs and desirable pressures for domestic service. *A. Hazen.*

19 Practicability of pressure tunnels for distribution systems of large cities. *W. W. Brush.*

20 Standard specifications for cast-iron pipe and special castings. *F. A. Barbour (As Chairman of Committee No. 9).*

21 Standard specifications for valves. *A. Wolman (As Editor).*

22 Standard specifications for hydrants. *A. Wolman (As Editor).*

23 Standard specifications for meters. *A. Wolman (As Editor).*

24 Standard brass fittings. *W. R. Edwards (As Chairman of Committee on Standard Brass Fittings).*

25 Summary of report on plumbing to United States Secretary of Commerce. *G. C. Whipple.*

26 Loss of head in corporation cocks and service pipes. *A. Wolman (As Editor).*

27 Corrosion of pipes. *A. Wolman.*

28 Practical aspects of electrolysis. *A. Wolman.*

29 Testing of water works materials and supplies. *T. H. Wiggin (As Chairman of Committee No. 12).*

30 Tabulation of water consumption in representative cities and meterage facilities in each. *V. B. Siems.*

31 Data as to requirements by manufacturers of public water supplies and influence on total water consumption. *V. B. Siems.*

32 Methods and records of water waste control. *W. W. Brush (As Chairman of Committee No. 13).*

33 Schedule of slides for meter rates. *I. S. Walker (As Secretary of Committee No. 14).*

34 Data on rates of water charges. *F. C. Jordan.*

35 Reasonable provisions for depreciation of water works. *L. Metcalf.*

36 Representative price trends for water works materials and labor. *D. F. O'Brien.*

37 Taxation for water plants in different States on physical property franchises, income and securities. *F. R. Berry.*

38 Summary of varying customs as to relation between the issuing of water works bonds of municipalities and legal limits of bonded indebtedness.

39 Historical review of formation of water districts and their accomplishments. *R. B. Morse.*

40 Standard form of contract. *J. Waldo Smith (As Chairman of Committee on Standard Form of Contract).*

41 Elements of valuation on water works properties; past and present practice. *J. W. Alvord.*

42 Need of balance budgets for municipal and privately-owned water plants in order to provide needed betterments and extensions. *G. W. Fuller.*

Topics related to fire protection

43 Summary of recent annual fire losses in the United States and foreign countries. *G. W. Booth.*

44 Rating schedule of National Board of Fire Underwriters for water supply and other public facilities. *C. Goldsmith.*

45 High pressure fire system. *C. Goldsmith.*

46 Reasonable charges for public fire protection service. *L. Metcalf.*

47 Reasonable charges for private fire protection service. *N. S. Hill.*

Topics related to quality of water

48 Self-purification of streams, lakes and reservoirs. *G. C. Whipple.*

49 Advantages of outlets at different levels for deep reservoirs. *F. E. Hale.*

50 Aeration. *W. Donaldson.*

51 Coagulation basins for colored waters. *M. Pirnie.*

52 Plain sedimentation basins. *J. R. McClintock.*

53 Coagulation basins for turbid water. *C. M. Daily and J. R. Baylis.*

54 Slow sand filters and appurtenances. *A. Hazen.*

55 Rapid sand filters and appurtenances. *W. Donaldson.*

56 Operating efficiency and economies of slow sand filters. *S. M. Van Loan and F. E. Field.*

57 Operating efficiencies and economies of rapid sand filters. *E. E. Wall and H. W. Streeter.*

58 Double filtration. *G. W. Fuller.*

59 Removal of iron and manganese. *W. Donaldson and M. Pirnie.*

60 Water softening by lime and soda. *C. P. Hoover.*

61 Zeolite treatment. *E. Bartow.*

62 Ultra Violet Ray treatment. *G. A. Johnson.*

63 Ozonization. *S. T. Powell.*

64 As to sizes of filtered water basins. *J. H. Gregory.*
65 As to need of covers for filtered water reservoirs. *G. C. Whipple.*
66 Summary of 30 years' practice with mechanical analyses of filter sands and gravel. *A. Hazen.*
67 Committee report on pressure water filters. *A. Wolman (As Editor).*
68 Summary of report of committee on colloid chemistry. *A. Wolman and F. Hannan.*
69 Current practice on chlorination. *L. H. Enslow.*
70 Current views on super-chlorination and dechlorination. *Sir Alexander Houston.*
71 Current practice with algaecides. *F. E. Hale.*
72 Current views on treating water supplies with iodide. *A. Wolman.*
73 Report on sanitary drinking fountains. *A. Wolman (As Editor).*
74 Records and essential data for water reports. *G. H. Fenkell and J. N. Chester.*
75 Topics dealing with management practice. *W. S. Cramer.*

THE CHLORINATION OF SMALL WATER SUPPLIES[1]

By M. F. Tiernan[2]

Heretofore most papers concerning chlorination of water supplies have dealt largely with developments in apparatus and means of applying chlorine and effects of chlorination upon mortality rates. A presentation of generalized experiences from actual operations of chlorine control apparatus would seem to the writer to be of interest to the water works fraternity.

From the standpoint of chlorination a small water supply is one requiring chlorine at the rate of 5 pounds or less per 24 hours—a supply of approximately one million gallons of water per day. Chlorination problems vary considerably with the various kinds of water supplies and the conditions under which chlorine is applied.

A review of the types and size apparatus which we have installed to date shows a ratio of the small supplies, or 5 pounds per day chlorination capacity, to the large supplies of approximately three to one. The number of units of chlorine control apparatus in operation on water supplies in the United States as of today is about 4200. The number of water supplies being chlorinated is about 3000 from which one must observe that the large use of chlorine apparatus is by the small water works.

We have found by experience that our greatest operating difficulties come from apparatus treating small supplies and a generalized analysis of the difficulties from such apparatus as compared with those of large supplies leads to rather interesting deductions. A review of our complaint files and general impressions gained from correspondence covering operating difficulties leads one naturally to classify the reasons why the small supplies seem to have more operating difficulty than the large supplies. These reasons may be classified as follows:

[1] Presented before the Water Works Manufacturers' Association Session, New York Convention, May 20, 1924.

[2] Of Wallace and Tiernan, Newark, N. J.

I. PERSONNEL

The writer deems it safe to say that the large cities have, as a rule, full time attendants to look after chlorine apparatus, attendants whose duties are devoted to this and nothing else. The small supplies, on the other hand, whether privately or publicly owned, often have only one or two men to do all sorts of work in connection with the operation of the water department and sometimes other departments—and these men's time and attention are so diversified that often the chlorine apparatus may be unintentionally neglected. The employee of the larger city giving all his time to chlorine apparatus naturally acquires a better knowledge of the care and operation of the apparatus and by more timely attention can forestall many difficulties which at a later day might assume serious proportions. The matter of inspection, cleaning, checking up, watching for leaks and minor operating details, is often neglected or delayed until the apparatus is in a serious condition and we find that this situation arises much more frequently in the case of the small than in the large supply.

II. LOCATION OF APPARATUS

The smaller apparatus may be located in any convenient or inconvenient spot as the case may be and it is sometimes difficult to secure a special house or housing for the apparatus under such conditions. Climatic conditions therefore affect the apparatus more severely and often when located in an inaccessible spot may be entirely neglected in extremely bad weather. In the case of the large supply chlorine apparatus can be taken better care of because usually there is more of the apparatus located at one spot and this location usually is such that it is accessible at all times of the year.

III. KIND OF OPERATION—CONTINUOUS AS AGAINST INTERMITTENT

One of the most serious operating conditions that chlorine apparatus has to undergo is that of intermittent operation. A chlorine apparatus operated continuously, that is twenty-four hours a day, will give much better service than when used for only a few hours a day. This is due to the fact that when chlorine apparatus is shut down for part of a day moisture may work its way back into the apparatus, where coming in contact with chlorine it will set up corrosion. Chlorine, as is well known, in contact with moisture will

corrode almost all metals. Furthermore the chlorine valves and tank valves are necessarily given more wear when turned on and off every day and the wear is usually quite severe because of the unusual force applied to the valves to shut off chlorine. The ordinary operator of chlorine apparatus wants to make sure that the valves are all closed tight and as a rule applies unusually great force to see that they are tight with consequent undue wear on the valves. Intermittent operation may also cause chlorine to condense in the apparatus more readily because of the change in temperature, causing more or less liability towards clogging, particularly if the chlorine should contain some impurities which were possible of condensing. Chlorine today is of such purity, however, that this difficulty rarely arises.

IV. GEOGRAPHICAL LOCATION

The writer has not yet found that chlorine apparatus operates any better or worse because of different climates. The operation in Canada, the coldest climate where we have apparatus, is as favorable as in Texas or in Panama. It is rare that complaints come in of apparatus freezing up, although with extremely cold water there may be formation of chlorine hydrate in the apparatus, both of the direct and solution type, that causes annoyance, but no serious difficulty.

For a supply of one million gallons per day, requiring say 4 pounds of chlorine per 24 hours, the flow of chlorine per hour is one sixth of a pound. The flow per minute is 0.045 or 1/22 of an ounce. The flow per second is 0.00074 of an ounce or 6.6 cubic centimeters. It is necessary to have the apparatus of such design and construction that this flow is constant for any second of time. When one considers that the initial pressure of chlorine may be well above 100 pounds and is then reduced to say 15 pounds and put through the control valve under a differential pressure of approximately 1 pound, the valve opening to allow a passage of 0.00074 ounce of chlorine per second must be of necessity extremely small. Many suggestions have been made that chlorine apparatus would be less liable to clog up if built larger and stronger, but the writer has yet to see a design of any reducing valve or control valve which restricts the passage conducting chlorine that could so alter the law of the flow of gases as to have a large orifice for a small flow. It does not matter what the wall of a pipe may be or the size of the handle of the valve. Minute flows can only be maintained by having minute openings and

low pressures and at the present time the writer's company is working to as low a pressure as is found by experience to be reliable.

In the apparatus of the solution type having a 5 pounds capacity of chlorine per day, the essential parts are: compensating valve, control valve, meter and constant pressure valve.

All of these parts have been developed after a great deal of experience and particular attention has been given to the design of a check or relief valve which will hold tight against moisture. When chlorine apparatus is operated intermittently the danger of moisture getting back into the apparatus is greater. There must be certain parts beyond the check valve where moisture is present and immediately when the flow of chlorine stops the water in the line dissolving the chlorine creates a vacuum in the line and creeps back to the check valve and very often works right through the seat of the check valve. When once through the seat of the check valve it can work back further into the apparatus and give all sorts of trouble.

The meter on the manual control solution feed type MSA apparatus is a volumetric meter of the inverted syphon type and is proving very satisfactory indeed. In an installation where a water pressure of 25 pounds per square inch is available, this meter is submerged in water in the apparatus, chlorine solution is then formed and applied to the water to be chlorinated. In small gravity supplies, where the pressure at the point of application is not excessive the same kind of meter is used and is submerged in a jar of sulphuric acid, which serves as a means of intermittently sealing and releasing the syphon. This was the first type meter employed back in 1913 when the writer's company was applying chlorine directly through diffusors at Dover, N. J., on a stream tributary to the Rockaway River. The meter is still used in the same way and with the same method of applying chlorine to water.

From the above recitation one would suspect that there is an unusual amount of difficulty with chlorine apparatus and consequently a prohibitive expense in the maintenance of apparatus. The writer feels that a true index to such difficulty or amount of difficulty and the cost of operation, exclusive, of course, of cost of chlorine passing through apparatus, can be best measured or arrived at by the maintenance costs of large numbers of apparatus. These costs are generalized costs and have been arrived at with the idea of getting a true index or figure of the cost of maintaining chlorine apparatus.

As an example of large water supplies we may take New York City, which today has installed on its various water supplies some 52 units. An examination of the maintenance and upkeep beginning with 1914 shows an average cost per year of $39.50, or 3.95 per cent upon an original installation cost of $1000 per unit. This $1000 per unit, of course, covers all the piping and auxiliary equipment that goes with the chlorine control apparatus and of course should be considered as part of the chlorine installation. An examination of the cost and maintenance of installations in 36 large cities in various parts of the United States, based upon actual installation figures and maintenance costs show an average of 3.6 per cent per year, or $36.00. The average cost of the apparatus being $1050. In the case of the smaller supplies and consequently smaller apparatus, an examination of 71 installations in various parts of the United States for an operating period of approximately five years shows an average yearly maintenance cost for repairs and overhauling of 7.4 per cent, or based upon an original installation cost of $450—$33.30. All these installations were taken at random, without any prior knowledge of the maintenance costs, the information concerning the location of installation and the costs of maintenance being obtained from entirely different sources in the writer's company.

These figures as a whole would seem to the writer to be very favorable in view of the corrosive nature of chlorine and the character of service that chlorine apparatus must render.

The operating cost for chlorine of 1 cent per capita a year is scarcely affected by the additional cost of maintenance and upkeep.

In the case of the new vacuum type chlorinator, or pedestal type as it is called, an examination of 22 installations for a period of approximately two years shows an actual upkeep cost of 1.8 per cent per year. This is due somewhat to the fact that the pedestal installations go into larger plants, but more to the excellent design and construction of the apparatus, and its more nearly perfect adaptability to the purpose for which is in intended.

As stated at the beginning of this paper a small water supply, from the chlorination standpoint, is approximately one of a million gallons a day. There are a great many supplies of 25,000 gallons or less per day, both publicly and privately owned, which should not be denied the benefit of chlorination because of lack of apparatus. Consequently the writer's company has developed an apparatus which

will reliably chlorinate a small supply, no matter how small or intermittent in its operation. Such a device should be simple, reliable and automatic and not prohibitive in price.

This new device is called a "chlorometer," because it not only chlorinates water, but it also meters the water and the metering means also proportions the chlorine to the water to be treated. The sterilizing solution employed is sodium-hypochlorite. This solution as employed in the apparatus at the present time is of 2 per cent strength, but can be used of higher percentages. The writer's company has been making it as strong as 6 per cent so that it would stand up with practically no deterioration for a period of six months in summer weather if kept away from the light. It is shipped in closed boxes which automatically exclude the light.

The apparatus consists of a hollow base in which an inverted bottle of sodium hypochlorite may be set. This arrangement maintaining a constant level of solution in a chamber in which a disc rotates. This disc has near its periphery small holes or recesses varying in number depending upon the capacity of the apparatus. It is partly submerged in the sodium hypochlorite, which solution as stated above is held at a constant level by means of the inverted bottle. The disc is connected to the gear train of a small water meter, the water to be treated flowing through this meter rotates this disc in proportion to the rate of flow. As the disc revolves through the solution the recesses in the periphery become filled with the liquid being maintained there by capillary attraction or surface tension. As the disc rotates it comes under a suction of an ejector which draws off the sodium hypochlorite and carries it to the point of application.

Variations in the amount or proportion of the sodium hypochlorite applied to the water may be secured by the variation of the size of the holes in the disc, the number of holes in the disc, the speed of the disc or the number and the width of the discs used. To secure a greater or less dose of sodium hypochlorite to the water to be treated the discs are changed to ones of larger or smaller capacity.

At the present time the discs are made with a range in capacity from 0.38 cc. sodium hypochlorite per revolution to 5 cc. of solution per revolution. A 1 inch meter, with 10 gallons flow per minute, will give one revolution of the disc. Using sodium hypochlorite of 2 per cent of available chlorine, requiring a dose of 0.2 part per million will require a disc having a capacity of 0.38 cc. of solution.

One gallon of a 2 per cent solution will treat 100,000 gallons of water. A disc having 100 recesses will divide 1 cc. into 100 equal parts, each disc retaining 0.01 cc. of solution. One revolution of a 50 recess disc per minute will therefore apply accurately 740 cc. per day or a quantity a little over a pint.

From the above it may be seen this apparatus will handle extremely low flows of water and apply the chemical required in solution in proportion to the water to be treated. The means of accomplishing this are simple, reliable and thoroughly positive.

This same apparatus can be used to apply any other chemical in solution, such as sulphuric acid, alum, soda ash, iodine, etc.

At the rate of 25,000 gallons of water a day, a 3 gallon bottle of 2 per cent sodium hypochlorite solution will operate twelve days at a cost of about 15 cents per day.

This apparatus is made of materials all of which are resistant to the action of chlorine solutions and is of such design that it is reliable. It is automatic in that it will vary the dose with the rate of flow. It is not subject to difficulties due to intermittent operation and its construction is such as to enable any water works operator to operate and take care of it properly.

For such supplies as camps, hotels, institutions, boats, swimming pools, etc. this apparatus is particularly applicable and thoroughly reliable. There are now approximately 12 of these machines in operation and they have given such success that the writer's company has no hesitancy in offering it to the public.

DISCUSSION

Mr. Edward E. Minor:[3] The information given us in Mr. Tiernan's paper is not only interesting but valuable. The danger from attack is not where the defenses are strongest, but where they are weak. The difficulties attending the small installation should be limited to those attendant on operation. This is seldom the case, due some times to financial and physical reasons and again to lack of a true sense of the importance of the work. The latter phase publicity will help or unpleasant experience cure.

The experience of New Haven in operating chlorinators may be of interest. We have eight supplies chlorinated, treating daily about

[3] General Manager, New Haven Water Company, New Haven, Conn.

30 million gallons of water. Five of these supplies may be classed as small. They are as follows:

Maltby treating 3,500,000 gallons per day—Automatic gas feed
Milford treating 650,000 gallons per day—pedestal type solution feed
Wintergreen treating 600,000 gallons per day—automatic gas feed
Branford treating 250,000 gallons per day—pedestal type solution feed
Prospect treating 250,000 gallons per day—constant gas feed

These supplies feed down to $\frac{1}{2}$ pound of chlorine per day. Their operation is reliable and efficient. They are checked daily by weight and frequently for residual chlorine. Feeding rates are established not only by bacterial counts, but by physical characteristics of the water supplied such as color and oxygen.

Maltby and Wintergreen operate on venturi control down to a very low rate. Operation is continuous and very accurate.

Milford is a manual control pedestal type operated in connection with a pumping station. The chlorinated water flows through condensers and then to the pump. Careful examination has disclosed no corrosion on the copper tubing of the condensers after more than eight years of service. Pumps are first started, then chlorinator turned on and this operation reversed when they are stopped.

Branford operates on a pumping load occurring at midnight and is in an isolated place with no attendant. Operation here is controlled by a movable vane in the water pipe which starts the solution jet when the velocity of flow moves the vane. This apparatus has worked perfectly for a number of years and is giving very good service.

Prospect operates at a point where no water pressure is available, where the hydraulic grade passes through the chlorine house, where a venturi offers too low a differential to operate a chlorinator —yet under these difficult surroundings a good measure of safety is afforded.

I mention these places to show that extremely low rates may be obtained and maintained with suitable supervision.

The actual time spent is small. The cost for results obtained is low. The results are positive. I believe small companies would do well to subscribe for continual and frequent inspections made by some expert either in the employ of the manufacturers or of the State Board of Health. Controls should be given for supplies based on a careful study of local conditions. This also should serve

as a school for local caretakers to care more efficiently for the apparatus.

I think the country at large owes a great deal to the firm of Wallace and Tiernan for the work and study they have put into this field of endeavor and to the organization they have developed to care for it. We have little realization of the tremendous responsibility and detail back of this great improvement in water supply work. The paper should be of the greatest interest to all engaged in it.

Mr. C. M. Saville:[4] I have read with great interest Mr. Tiernan's very interesting and instructive paper. Founded on the long experience of an efficient organization, the statements and conclusions stated in the paper are well worth careful consideration.

The desirability of a full time operator in order to get the best service cannot be too strongly stressed, as an automatic machine is only efficiently automatic as long as it is under intelligent supervision.

The author's statements in regard to the matter of minor operating details are most timely and emphasize the necessity for frequent routine inspection. The Hartford (Conn.) water department was among the first to install chlorine gas sterilizing apparatus of the Wallace and Tiernan type and the experience both with the operation of the machine and the attention of the makers has been most satisfactory in every respect.

Previous to the installation of the filters in 1921 Hartford's water supply was treated with chlorine gas to the average amount of 0.76 p.p.m. or 6.3 pounds per million gallons of water. Normally from 0.5 to 0.7 p.p.m. was used, but following heavy rains or freshets the amount was increased to 0.8 p.p.m. and maintained at that rate until the water in the reservoirs showed normal bacterial count. All of the B. coli type of bacteria were eliminated, and an average of about 92 per cent of other types. It is of interest to note also the improvement in color of the water supplied after chlorine treatment.

For the year 1919–1920 the monthly average color of the raw water was from 23 to 39 p.p.m. (Platinum-Cobalt scale), with an average of 30, while the color of the water after treatment ranged from 20 to 35 with an average of 27. The color reduction for the year averaged about 10 per cent.

After the filters were put in operation the necessity for chlorination passed so far as ordinary protection of the city was concerned.

[4] Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn.

Nevertheless, it was deemed inadvisable to discontinue entirely the use of the chlorine gas plant, as it was felt that there should be some safeguard provided for the remote contingency of an interruption of filtered water service. On this account the apparatus is continued in service constantly, working under a load of 0.1 p.p.m. This quantity is maintained not for the purpose of sterilizing the water, but in order that the machine will be ready for instant service in an emergency. The operator visits the plant twice a day to see that all is running smoothly, and that is the extent of this service, the security of operation for emergency being held to be well worth the cost of gas and attention.

This is, of course, in line with Mr. Tiernan's caution that best results are obtained by constant rather than intermittent operation.

SUPERVISION OF WATER TREATMENT PLANTS IN MICHIGAN[1]

By Edward D. Rich[2]

An enactment of the Michigan legislature in 1913 gave the State Board of Health supervisory control over all public water supplies of the State. This act provided among other things that the State Board of Health should have authority to make and enforce such rules and regulations as it deemed necessary in the interest of the public health for the proper operation of water works systems. The law gives the State Board of Health considerable authority which carries with it a corresponding amount of responsibility.

About the time that this law was passed by the State legislature there was a widespread interest throughout the country in the sanitary quality of public water supplies. This may have been due to the discovery in 1908 of the effect of small amounts of chlorine when added to water, thus making it possible to disinfect entire public supplies at a reasonable cost. The first use made of chlorination in Michigan was at Menominee in 1910.

Almost the entire state of Michigan is covered with a deep glacial drift largely deposited as terminal moraines. These formations as well as some of the underlying rocks yield abundant supplies of water usually of a potable character, though often so hard as to render their use disagreeable and expensive. Lakes are numerous throughout the State, many of which are used as the source of water supplies. The four great lakes which border the State are extensively used for the same purpose.

Although the State is not densely populated, few, if any, of our surface water sources can be considered safe at all times for domestic use without some kind of treatment.

[1] Presented before the Iowa Section meeting, October 24, 1923.

[2] Director, Bureau of Engineering, Michigan Department of Health, Lansing, Mich.

The water supply situation in Michigan is summarized as follows:

Total Number of Public Water Supplies........................ 305

Ownership

Municipal..	270 or 88.5 per cent
Private..	30 or 9.8 per cent
Combined..	3 or 1.0 per cent
State..	1
Federal..	1

Source

Ground water. .201 or 65.9 per cent serving population of 645,280
Surface water. . .104 or 34.1 per cent serving population of 1,881,620

Treatment

Filtration with chlorination..... 13 serving population of 354,200
Filtration with chlorination to be installed within 1 year.. 4 to serve 1,220,800
Chlorination only............... 50 serving population of 1,663,700

The population of Michigan in 1920 was 3,668,400, 61.1 per cent of which is urban and 38.9 per cent rural.

The population served by public water supplies was 2,526,900 or 69 per cent.

The popu`ation served by treated water supplies was 2,017,900 or 55 per cent.

Fourteen ground water supplies are treated with chlorine either occasionally or continuously. Five of these are from deep wells which show some signs of contamination part or all of the time, probably from defective casings or abandoned wells. One is from rather shallow wells near many dangerous sources of contamination such as sewers, privies and cesspools. In two cases such conditions formerly existed but deeper wells have been put down and the supply improved. Five supplies are from rather shallow wells near sources of contamination not positively dangerous, such as polluted streams. One has a long suction main passing through polluted water and liable to inward leakage.

All filter plants in the State maintain their own laboratories. Of the 50 chlorination plants, 41 have analyses made regularly, 33 in laboratories maintained by the municipality and 8 in other laboratories of recognized standing, none of these being of the commercial type. In four instances the chlorine dosing apparatus is kept for emergency use and regular analyses are not required. In

two places chlorination has been installed recently and laboratory service has not yet been established. In only three cases are cities delinquent in conforming to state requirements in respect to laboratories.

When attempting to supervise water works systems for the purpose of controlling the sanitary quality of the water delivered it is decidedly important that the supervising body know the exact quality at all times and that some one directly connected with the water system be made responsible for maintaining the required quality. To accomplish this the State Board of Health adopted a resolution which requires that after January 1, 1916, whenever a water supply is subjected to treatment of any kind to improve its sanitary quality, the management must provide facilities for making laboratory examinations as frequently as deemed necessary by the State Board of Health and that the results of these examinations must be forwarded to the Board each month on blanks furnished by the State.

Of course some difficulties were encountered in attempting to establish laboratories at each treatment plant and it was often difficult to find the proper person to place in charge of them. At the present time there are 50 laboratories in the State making water examinations regularly for 54 water systems and the results of these tests are reported each month to the Michigan Department of Health. The examinations are made as nearly as possible in accordance with methods adopted by the United States Public Health Service for determining the sanitary quality of water used for drinking purposes on interstate carriers and the standards recommended by the United States Public Health Service are used as standards for the water supplies of the State.

One could hardly expect each laboratory to do scientific work of the highest order, but it is significant that, so far as can be learned, even in the laboratories at the smaller plants the results continuously correspond very closely to those obtained from samples occasionally collected and examined in the Laboratory of the State Department of Health at Lansing. By using prepared dehydrated media the bacteriological plantings are made comparatively simple and it has been found that by having some one from the State Department of Health spend about 2 days with some intelligent local person, sufficient instructions can be given to enable him to carry out routine plantings and properly fill out the report blanks. Whenever reports

show that the analyst is in need of further instructions, or upon request, other visits are made and assistance freely given.

It has been found important in giving the first instructions to follow closely routine procedure only. The analyst is not asked

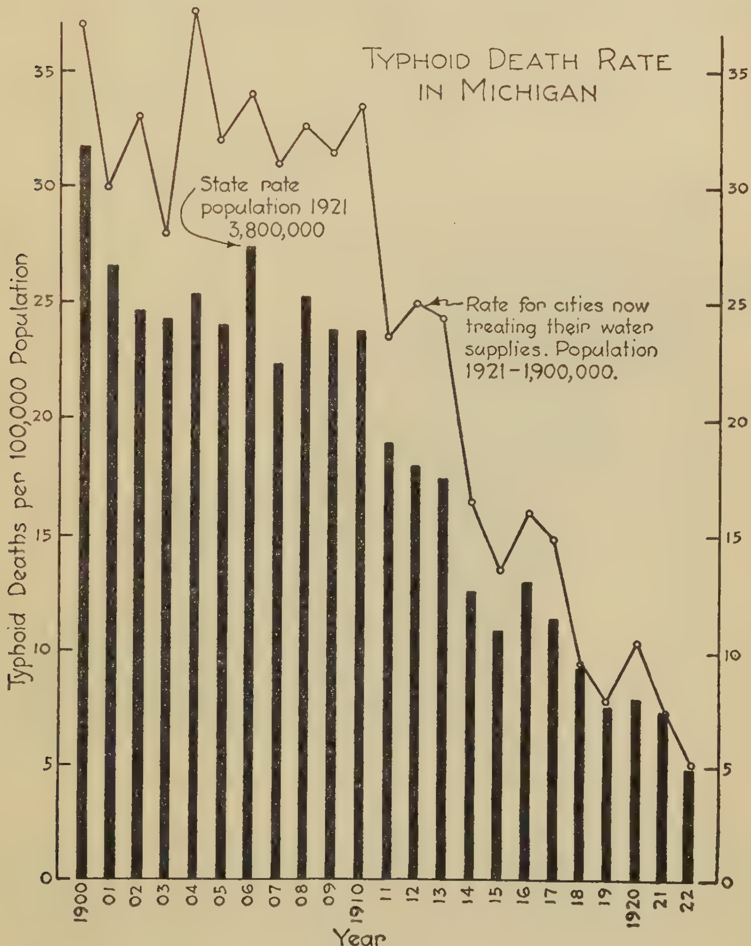


FIG. 1

to interpret results, but is simply required to record his findings on the report blanks. After he has had time to become acquainted with routine procedure we make all reasonable efforts possible to give instructions in interpretation of results in and the cause and effect of water supply contamination.

Some of our laboratories are located in high school buildings where one of the teachers performs the analyses and usually this has proved satisfactory where part time services must be accepted. This arrangement has decided educational advantages well worth considering. During the vacation season some teacher remaining in the city or a high school student is placed in charge of the work.

The rapid decrease in typhoid fever in the State during the past ten years and especially in the cities which in former years had

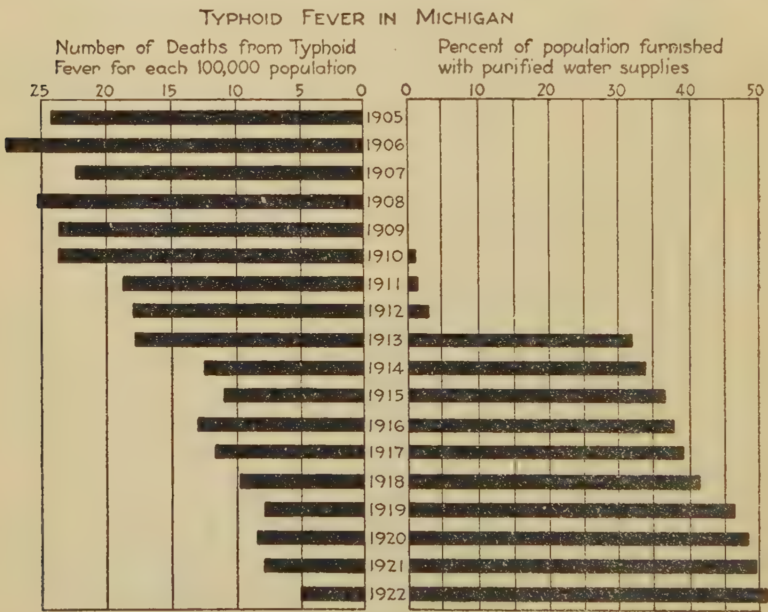


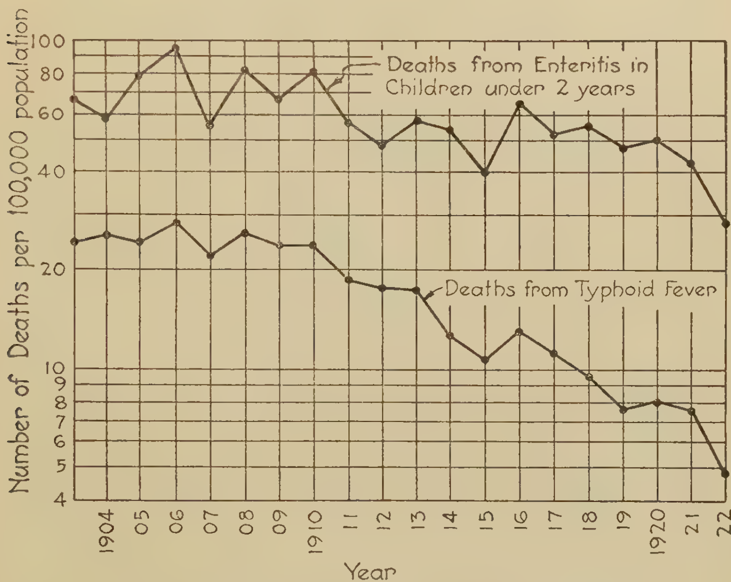
FIG. 2

very unsatisfactory water supplies has apparently shown good results from our efforts. This is illustrated by figure 1 which shows that in 1913 the death rate for this disease was 3.6 times the rate for 1922 in the State as a whole and 4.8 times the rate in the cities which now treat their water supplies.

The relation between the typhoid death rate of the State and the percentage of the population using treated water is shown in figure 2.

A parallel relation shown in figure 3, between deaths from enteritis and from typhoid fever in children under two years of age, may indicate that our water supplies are still in need of more careful

treatment even though water-borne typhoid seems to have been largely eliminated. A comparison of the death rate from enteritis in cities of the State using well waters and in those using treated surface waters does not show, however, a greater prevalence of this disease in the one than in the other.



DEATHS FROM ENTERITIS UNDER 2 YEARS AND TYPHOID FEVER

The above graph shows a striking relation between Enteritis under 2 years and Typhoid Fever.

Since the incidence of each is so closely related to the other, a common contributory cause is apparent.

To laboratory workers, this should suggest the importance of more general bacteriological examinations of feces from children under 2 years, reported to be suffering from diarrhoea and enteritis.

FIG. 3

THE CHEMISTRY OF INTERIOR BOILER WATER TREATMENT[1]

By. E. M. Partridge[2]

This subject is one, which for full discussion, would require more time than the period now available. Chemicals are added to water for various purposes—to render a water non-corrosive, to check foaming and to prevent the formation of scale. If these chemicals be added to the water outside the boiler and any insoluble reaction products formed allowed to separate from the water, the treatment is external. If the added chemicals together with the water treated are allowed to enter the boiler together with no separation from the water of any substance, the treatment is internal. Internal treatment is usually given through the use of boiler compound. I wish to discuss in this paper only that phase of the matter which has to do with the prevention of scale in steam boilers by the use of compound.

Before entering upon a discussion of how to prevent the formation of scale it may be well to mention the cause of scale. Boiler feed water contains dissolved mineral matter which, driven from solution by the heat and pressure in the boiler together with the concentration naturally occurring through the evaporation of water as steam, deposits in insoluble form on the boiler parts in contact with the water. The dissolved mineral matter which causes scale to form is identical with that which causes hardness in the water. The two things are closely related, the type of scale which forms being to a large extent dependent on the chemical identity of the salts present causing hardness. Hardness is conveniently classified as being either temporary or permanent. Temporary hardness is due to the presence of the bicarbonates of calcium and magnesium and is so called because it is more or less completely precipitated by simply boiling the water containing it. Permanent hardness, caused ordinarily by the sulphates of calcium and magnesium requires the higher temperature existing in the boiler to precipitate it as scale.

[1] Presented before Illinois Section meeting, March 20, 1924.

[2] Chief Chemist, Paige and Jones Chemical Co., Inc., Hammond, Ind.

As a usual thing, carbonate or temporary hardness deposits a soft and porous scale and sulphate or permanent hardness a hard and dense scale. This is not always true—under the proper conditions carbonate hardness may deposit an extremely dense, hard scale and sulphate hardness may drop out of solution as a sludge. The mention of the conditions under which these apparently unusual results may occur will bring out a fact which is of profound interest when the prevention of scale formation is considered.

In condensers, the cooling jackets of internal combustion engines and similar places where it approaches but does not exceed the boiling point in temperature, water containing carbonate hardness may deposit that carbonate hardness as a very compact, hard and non-porous scale. A water containing both carbonate and sulphate hardness may in a low pressure heating boiler deposit a hard carbonate scale with but little sulphate hardness.

In a boiler operating at higher pressure, the higher temperature will drive the carbonates more quickly from solution and much of it will appear as a sludge at the bottom of the boiler, while the scale formed will contain more calcium sulphate. At very high pressures, the sludge will begin to contain calcium sulphate removed from solution too quickly to form into hard scale. I have with me for your inspection three pieces of exceptionally hard scale. One is from a condenser and is 94 per cent calcium carbonate. Another is from a very high pressure boiler and is 94 per cent calcium sulphate. The third is from a medium pressure boiler and has about twice as much calcium sulphate in it as it has calcium carbonate. The point that should be especially noticed about these scales is that they are all highly crystalline. Under conditions which allow the scale forming material to deposit slowly and in crystalline form, hard scale will form. The fact which is of importance is that hard scale is crystalline scale and if crystallization of the scale forming matter can be prevented, it will deposit not as a scale but as a sludge.

One method of hindering the crystallization into hard scale of the scale forming matter, is to add soda ash to the boiler feed water. Soda ash or sodium carbonate when added to water containing permanent hardness converts that permanent hardness to temporary hardness. Thus soda ash added to a solution of calcium sulphate forms calcium carbonate which precipitates and soluble sodium sulphate.

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$

By the use of soda ash, therefore, any permanent hardness in the water which might otherwise form hard scale is converted to temporary hardness and this together with any temporary hardness already present in the water forms a less objectionable deposit in the boiler than if the soda ash were not added. An excess of soda ash over the amount necessary to account for the permanent hardness insures the quick precipitation without crystallization into scale of the totally carbonate hardness then present.

The use of soda ash in this manner is beneficial, especially when waters of low sulphate hardness and small mineral solid content are to be treated. With hard waters to which it is necessary to add considerable soda ash, considerable sodium sulphate is necessarily formed and this together with the excess of soda ash added to insure quick precipitation and the sludge deposited by that precipitation makes the boiler apt to foam. Also, when the water is of high hardness incomplete elimination of scale occurs.

There is another method now practiced which makes the use of compound with hard water extremely practical and especially so where waters high in permanent or sulphate hardness are to be treated. It is the addition of colloidal matter to the boiler feed water to prevent crystallization of the hardness into scale. The advantages are the small amount necessary for use and the correspondingly small increase in the total solid content and especially the sodium salt content of the water treated. No excess of alkaline material is added and the danger of foaming is reduced to a minimum while the other wise scale forming matter is deposited as a soft sludge which can be easily removed from the boiler by blowing off or washing out.

"Colloidal" matter is a term rapidly becoming common as the importance of colloidal phenomena becomes more familiar through the intensive study now being given the subject of colloidal chemistry. There are numerous substances which go into apparent solution in water, but an examination of the water by means of an ultra-microscope shows that the material has gone into a state of very fine suspension rather than true solution. Thus gelatine dissolved in water gives to the eye or to an ordinary microscope a clear solution, but the ultramicroscope which examines the solution with the aid of a small, but intense, beam of light reveals the presence of small particles

just as a shaft of sunlight into a darkened room shows the dust particles floating in the air. A substance going into true solution does not reveal these particles even with the ultra-microscope.

Under the proper conditions, matter in colloidal solution or suspension is readily adsorbed at the surface of any larger particles suspended in the solution. For the benefit of those who are not familiar with the term adsorption, it may be stated that adsorption differs from absorption. A blotter or sponge absorbs water taking the water into it, but adsorption is a surface phenomenon; thus a plate of glass will be found to have a layer of adsorbed air on its surface. Powdered charcoal is an excellent adsorbent and liquids filtered through charcoal are often freed from impurities which are adsorbed on the surface of the particles of charcoal. If some water be colored by the addition of a little of some dye such a methyl violet and the colored liquid shaken with some powdered charcoal, filtering or centrifuging off the charcoal will leave the water colorless again. The dye will be retained by the charcoal which will be found to have adsorbed it.

Thus a finely divided substance in suspension in a liquid may adsorb matter dissolved in that liquid. Colloidal matter dissolved in water has been found especially likely to be adsorbed. Now consider what happens in the boiler when hard water is employed. The hardening salts when driven from solution first appear as minute particles in suspension before they become attached to the boiler parts and crystallize into hard scale. If colloidal matter be present it will be adsorbed on the surface of these particles while yet in suspension and prevent their union and growth into scale. As far back as 1913, Edgar T. Wherry, then Associate Professor at Lehigh University, and George S. Chiles, Mechanical Engineer for the American Steel Foundries, published the following in the Engineering Magazine.

> That it is possible to prevent the formation of boiler scale by the addition of certain substances to the water in the boiler is now quite generally conceded by operating engineers, but chemists often ridicule the practical man for using things that in their opinion can have no chemical action on the scale forming salts.

They then go on to point out that many of the substances found in boiler compounds—potatoes, tannins, glue, etc., are colloidal in nature, and undoubtedly prevent scale formation by preventing the

crystallization of the scale forming salts. Quoting from their paper again, we read the following:

It has been found that the various changes which a colloid may undergo, deposition from a state of suspension, coagulation and hardening in their various states, and the reversion to the crystalloid condition can be greatly retarded, if not altogether prevented by the presence in the surrounding liquids of certain other colloids such as glue, gelatine or tannic acid.

Just how the adsorbed colloidal matter prevents crystallization of the matter adsorbing it, is a matter of dispute. Some say that its adsorption lends the particle an electric charge that keeps it away from the other particles in suspension which under the conditions will bear a similar charge. Another view is that the adsorbed matter is simply a film around the particle through which the enclosed mineral matter cannot push to unite in crystalline form with that of neighboring particles. Still another view is that the adsorption of matter at the surface of a small particle so modifies the surface energy that the forces which ordinarily cause small bodies to build up a larger crystalline particle are weakened or overcome.

In the past, the difficulty in the application of such treatment has been that the nature of the treatment and the result strived for has been incompletely understood. The best material to use under varying conditions was not known. The result was that an excess of material had to be added to insure the presence of sufficient active material to gain the desired result. The excess of matter added fouled the water and made the sludge deposited apt to stick to the boiler parts and cause overheating. Now that the mechanism of the process is appreciated, it has been found possible to sludge the otherwise scale forming salts with the addition of only small amounts of especially chosen colloidal matter. So little is added that there is no danger of a burned boiler. As much as three times the necessary amount has been added by mistake at a plant where an already exceptionally heavy treatment was being given without any harm resulting.

An idea of the amounts being used may be gained from the following figures. A water containing

	grains
Calcium carbonate	3.50
Calcium sulphate	2.31
Magnesium sulphate	2.39

and which would require about 0.78 pounds lime and 0.54 pounds soda for lime-soda treatment, or one pound of chemical for about each 750 gallons of water treated, is treated satisfactorily by compound with one pound to 4500 gallons.

Again a water containing,

	grains
Calcium carbonate	9.60
Calcium sulphate	0.58
Magnesium sulphate	5.34

and which for lime-soda treatment would require per thousand gallons 1.87 pounds lime and 0.83 pounds soda or a pound of chemicals for each 400 gallons of water is satisfactorily treated by compound using one pound per three thousand gallons. These two examples indicate that on average water compound achieves its results with from a sixth to a seventh the amount of chemicals necessary for lime-soda treatment.

The statement was made that the treatment was especially adapted to use with waters high in sulphate hardness. Softening such a water by external treatment causes the presence of a large amount of sodium sulphate in the softened water This being in solution cannot be settled from the water but enters the boiler. It concentrates as the water evaporates and may be the cause of foaming or corrosion. Because it is in solution and equally distributed through the water in the boiler, the amount present can be reduced greatly only by extensive blowing off of the boiler water. If compound be added which precipitates the chemically unchanged calcium sulphate as a sludge, the boiler water can be kept relatively clean since the sludge settles near the bottom of the boiler and can be removed by blowing off but a small portion of the water necessary to reduce appreciably the sodium sulphate content of the water.

By these remarks, it is not intended to imply that compound treatment is always the best. Some waters are much better adapted to treatment by one method than by another. Circumstances other than the character of the water may sometimes indicate the treatment to be chosen. In choosing a method of treatment all methods should be considered in consultation with a specialist in the field of water treatment. It has rather been the intention to point out that boiler compound or interior treatment is no longer a hit or miss proposition in the hands of unscientic individuals, but is on a firm scientific basis and in the hands of experienced technicians has become one of the most important of water treating methods.

DISCUSSION

In answer to Dr. Hatfield's question Mr. Partridge stated that the boiler compounds used by his company were not composed entirely of colloids, some of the compounds contain considerable soda ash, although other formulas contain no soda ash or other alkaline substance at all. The colloids found most useful by him were the tannins. Mr. Behrman stated that, while in many cases the use of boiler compounds was advantageous, it would be found in general that outside treatment was less expensive. While enough chemical is added in the outside treatment to soften the water completely, the smaller amount of chemical used in boiler compounds is especially prepared and more expensive per thousand gallons of water treated. Interior boiler treatment is especially advantageous in small plants and in cases where the hardness is rather low. Mr. Partridge replied that the use of boiler compounds was not limited to moderately hard waters, but that it frequently found its greatest usefulness in exceedingly hard waters where exterior treatment would produce such a high amount of non-incrusting solids that the water would foam. Interior boiler treatment does not greatly increase the non-incrusting solids. Compound costs more per pound than lime and soda, but less is used and no expensive treating plant is required. If this be considered, the cost per thousand gallons is low. Mr. Mabbs pointed out that heat alone caused the separation of incrusting solids at the surface of the water in the boiler and cited the advantages of using a skimmer. The Chairman called attention to the fact that the reactions produced by boiler compounds were different both in character and extent from the reactions which take place in complete exterior treatment. Lack of appreciation of this point lead chemists to condemn interior boiler treatment on the basis of the fact that too small an amount of precipitant is added. Mr. Partridge's statement that only one-seventh to one-tenth of the calculated amount of precipitant of the required when colloids are also included clears up much of the mystery surrounding interior boiler treatment. Unfortunately there are many quacks in the business. There apparently is much sound scientific basis for the treatment in certain cases.

PACKING[1]

By John W. Mabbs[2]

The question of packing frequently is not given the consideration it deserves either by the manufacturer or the operating engineers. If the damage to rods and plungers caused by certain almost universally used packings were charged against the packing, it would make their cost prohibitive. You all know that flax, hemp, or jute, if allowed to remain in the stuffing box long enough will become so hard as to wear and often cut and groove the rods and plungers. It is necessary to remove these types of packing from time to time in order to prevent the rods and plungers from becoming grooved.

In the design of stuffing boxes for pumps, there is one general principle which is not always observed, and that is, the higher the pressure handled, the deeper the stuffing box should be; or, in other words, the higher the pressure, the more turns of packing there should be in the stuffing box. Frequently a larger packing is used than should be, for the larger the packing the fewer the turns a stuffing box will hold.

In the design of pumping machinery a certain depth of stuffing box may be found advisable, and if a smaller packing were used, more turns of packing could be used without increasing the depth of the stuffing box. This principle is much more vital in case of hydraulic presses than in ordinary pumping machinery used in connection with water works.

The packing desired is one that will not become hard or glazed and will not cut or score the rods and plungers. Such a packing is found in braided rawhide, and this packing has the additional advantage that, when it is saturated, it is too soft to hold the particles of grit and dirt upon its surface, but they work back into the body of the packing, thus preserving the metal surfaces from wear and cutting. In any packing, it is the particles of grit that the packing holds upon its surface, when it becomes hard, that really damage the metal

[1] Presented before the Illinois Section meeting, March 19, 1924.

[2] President, Mabbs Hydraulic Packing Company, Chicago, Ill.

surfaces. This is particularly noticeable in plants where there is more or less sand or sediment in the water, and also in sewage disposal plants where dirty water is being constantly handled. Another great advantage in favor of rawhide packing is that it greatly reduces the friction load. Rawhide when it is saturated is as slippery as an eel. It is, therefore, practically antifrictional.

I have known of cases where, with rawhide packing used continuously on brass rods, the rods have outworn the pumps. You will all appreciate what this means when usually a pump will outlast three sets of steel rods. Rawhide packing works equally as well on centrifugal as it does on reciprocating pumps. It preserves the shafts from being grooved and cut. This is forcibly illustrated by the fact that the United States Government has been using rawhide packing on their hydraulic dredges for the past twenty years.

When water that is comparatively clean is being handled, rawhide may become a perpetual packing, for the old packing never has to be removed. All that is necessary is to add a ring of new packing, when there is room, to compensate for the slight wear.

Rawhide packing weighs only about two-thirds as much as flax, and notwithstanding the fact that its first cost is higher than many other packings, when its long life and antifrictional qualities are taken into consideration, it becomes one of the cheapest packings that can be found.

Certain water works on the Ohio River (where there is more or less sediment in the water) have been using a brand of rawhide packing for over thirty years with most gratifying results. Another field where this type of packing has shown wonderful results is the packing of the stems of hydrants and valves, both hand and hydraulically operated. In one case I have in mind, where hydraulically operated valves were packed with flax, it was necessary to boost the hydrant pressure from forty to eighty pounds in order to operate the valves, and after these valves were packed with rawhide packing, the booster was never used again. When this packing is used on hydrants, it makes the hydrants operate more freely and becomes almost a permanent packing.

Rawhide packing proves an ideal proposition on the stems of water meters. In this position, it practically eliminates all friction and makes almost a permanent joint.

ALLOCATION OF WATER SUPPLIES DERIVED FROM THE WATERSHEDS OF INTERSTATE STREAMS[1]

By Morris Knowles[2]

The author, Mr. Wood, has raised some very interesting technical and legal questions. He thus has performed an excellent service in bringing to our attention the fact that there are so many occasions where interstate comity was promoted and a much more economical and efficient accomplishment of securing water supplies than the present difficult situation of communities within each state placing reliance solely upon development of resources within the state lines. The latter frequently leads to the abnormal and awkward situation of a place going far afield for a suitable and sufficient supply of water when right at hand, but over the state line, there may be an abundant supply of greatest purity; and which at the same time has no particular use in the neighboring state because of the lack of large centers of population to demand much use of water.

Perhaps an illustration in a slightly different field may be of interest to the members of the Association. For a long time the Pittsburgh district has been studying the subject of flood prevention and the regulated use of the streams. While beginning with the idea that the local situation as to damage was an important consideration and, in fact, the moving one to cause attention to the problem, it early became evident that the proper answer to the question would come only when streams are considered as a whole from the source to the mouth, and that, in many instances, works of regulation would have to be constructed in neighboring states in order thoroughy to meet the situation.

The Pittsburgh Flood Commission ascertained that it was possible to develop reservoirs at 43 different sites on the Allegheny and Monongahela Rivers and thus very greatly conserve the flow of the

[1] Presented before the New York Convention, May 20, 1924, as discussion of the paper by the same name by L. P. Wood, Journal, May, 1924, page 521.

[2] Consulting Engineer, Pittsburgh, Pa.

streams, increase the low water discharge for the benefits of water supply, sewage dilution and navigation and at the same time prevent the disastrous floods in the spring. Seventeen of these reservoir sites were selected as most important and efficient ones to develop. Several of these are not within the confines of the State of Pennsylvania, being located in West Virginia, Maryland and New York. This has led to the consideration of the interstate elements of the problem, as well as causing a retarded progress in the execution of works.

The necessity of the cooperation of interests other than those located within the State of Pennsylvania are at once evident and this has led to the national consideration of the problem, with the idea of bringing about a solution through the direction of a major interest or else with the cooperation of several states. The federal government, through the application of the Forest Service Bill has acquired several thousand acres of land upon the watersheds of the Allegheny and Monongahela Rivers not all situated within the State of Pennsylvania. These lands will not only be developed with forests which will conserve the flow of the streams, but at the same time within their area are located some of the selected reservoir sites. Thus the acquirement of land, when it comes time for construction, will have been made easy.

In addition to this there is a recognition of the necessity of a higher power to investigate the entire situation. It has naturally been thought that the engineers of the War Department, having charge of navigable streams, should do this work. The state of Pennsylvania, however, has already appropriated $25,000 for the purpose of such survey and investigation. The national Government has considered the appropriation of a like sum, for the purpose of using it with the money contributed by Pennsylvania so that adequate studies may be of a national and interstate character. These will determine the reasonableness of building such reservoirs upon interstate streams and under a control higher than that of a single state and for the benefit of people in several states. The Bill known as H. R. 8070, carrying this appropriation, is now pending in the Senate, having been affirmatively reported out of the committee. It is expected that this will pass and serve as a precedent, as well as an incentive to solve this troublesome stream regulation problem upon interstate streams.

The writer is familiar with another situation of a somewhat different character, but more nearly allied to those which are described by the author of the paper. He refers to the supply of Lawrence, Methuen and vicinity in the Merrimac River Valley in the northeastern portion of Massachusetts and closely adjoining the New Hampshire line. Lawrence has a water supply derived from the Merrimac River, which is filtered. Methuen has a well supply derived from two different sources. Both supplies need attention, augmentation and perhaps substitution from entirely different sources. The facilities are inadequate and the supplies, although entirely healthful, are objectionable from one point of view or another.

Studies made by the writer and his organization, extending from 1917 to date, indicate that very advantageous and efficient supplies can be obtained from watersheds in the vicinity, although several of them are either within or extend over into borders of the State of New Hampshire. Several of the areas suitable for supply are so manifestly within the control of authorities in the adjoining state that their suitability for supply of communities within Massachusetts is extremely doubtful under present conditions of state comity and legal situations as to control of supplies in an adjoining state. There are others, notably the Bartlett Brook Supply, which is good for so long a time without additions that it may be expected that at such a time new ideas may prevail with regard to this subject of interstate exchange of waters, so that the usefulness of the supply seems to be in a somewhat different class than some of the other sources. In addition to this, it is possible that the gathering of the additional water for the future extensions would occur with a foreign state and that the entire control of the final storage and treatment and thus the purity of the water could be controlled within the State of Massachusetts.

But, be that as it may, the bugaboo of the difficulties of obtaining a suitable water supply across the state line has so worried the public mind that there are questions raised as to whether the new sources of supply for Northeastern Massachusetts should not be by a much more distant, expensive and difficult means; viz., by attachment to the large Boston Metropolitan Water District. Thus is brought in all of the antagonism of the central and western counties which feel that water should not be carried long distances across the state when the means exist near at hand, even though they may cross the state lines.

As the author has so well pointed out, this is an extremely important problem whether we are to let any longer the difficulties of state boundaries interfere with the easy, efficient and economic means of distributing and allocating water supplies, just because of this barrier of the state line. For to do so will cause us to go long distances within a given state which is not only inefficient and indefensible from any engineering point of view, but financially unsound. It is indeed a question which demands the attention of the best minds and, as so often happens, if engineers focus attention upon the problem, it is likely that the lawyers and the legislators will find a method of accomplishment.

PUMPING STATION BETTERMENT[1]

TOPICAL DISCUSSION

Mr. W. S. Cramer: Possibly some of you who have lost heart in not getting quite what you might have out of your old plant may be interested in a little resume of what we have done in past years with the high cost of coal in plant operation. We have gone into our boiler plant, particularly, and have added almost everything in the way of a contrivance in the most uptodate plant today. We have a continuous recording CO_2 thermometer, recording thermometer on the feed, a water feeder to the boiler and recording hydrometer in the uptake and with proper draught regulator. We find that we have saved between 20 and 25 per cent on our coal by these devices. In connection with those we have a Venturi meter and they run a continuous test on the evaporation per pound of coal. We are paying a bonus to our firemen on the basis of weekly evaporation, and that we figure has saved at least 15 per cent in our coal. It is the best thing I ever tried in our plant, and I think it is worth taking up; the expense of installation is very small considering the results you get. We have been adding just a little new material all along the line of later development as we can finance it, and in doing that, our old plant was very compact to start with, the proposal came up of installing a new Stirling boiler with about 300 horsepower, but it was impossible to install this unit and keep our plant going on account of cutting in our boiler capacity, unless we built an addition to our boiler plant, lengthened our steam line and put the new unit in a very undesirable location. To overcome that we bought a 300 horsepower Stirling engine, connected it to 3,000,000 gallon centrifugal pumps and used that as a standby service. I think, for as much as 18 hours at one time, we ran that in making our changes to connections and also to carry us over the standby of taking up out of the second boiler. We also found, first, that, while the gasoline outfit cost us about $9000, we saved it entirely in the cost

[1] Presented before the Superintendents' Session, New York Convention, May 23, 1924.

of additions to our building and changes we would have had to make otherwise. Now we have our Stirling boiler within 20 feet of our main battery of engines, giving very short steam lines and almost an ideal installation. The Underwriters are giving us a better credit for that gasoline unit than they would for a pump of the same size. It is detached from the house and they put great stress on that and give us an unusual credit for it. This gasoline engine also tided us over the taking out of one pump and putting in a larger one, and we found it a great help in many ways. As I say, I did not prepare a paper, for I did not understand that that was the thing to do, but I was merely to bring about some discussion and emphasize the fact that, however old your plant is, you can tune it up by installing modern appliances.

We are operating a hand stoker and have been getting very good results in connection with a Stirling boiler. One thing we have, that possibly a good many of you have not, is the fact that there is a State University located at Lexington and we leave our plant open the year round for them to make boiler tests. At this time we have at least three of the students that have a thesis on some part of the plant. That means that we have a testing of the entire plant at least once a year, with some of the units tested several times a year. That has helped us keep a check on our plant as well as on our coal consumption and boiler performance.

Mr. James E. Gibson: At Charleston, S.C. when we took over the plant seven years ago, we were obtaining an overall station duty of 35,000,000 foot pounds per 100 pounds of coal. The plant was built with good machinery, but it had not been properly taken care of. The company had been losing money, and when we lose money we do not spend much on maintenance and repairs, if we can get along without it. In the last seven years we have brought the overall station duty, including low-lift pumps, electric light engine, auxiliaries, etc., up until we are now getting approximately 70,000,000 foot pounds duty per 100 pounds of coal, burning West Virginia high volatile coal. The boilers are of the Stirling type and were originally set with the low type setting. Recently we have torn these out and have built Dutch Ovens, increasing the combustion space about three times over that of the original setting, and by so doing we have made a material increase in the economy on coal consumption.

Mr. Chas. E. Moore: There is one question I should like to ask: below what boiler horse power is it impracticable to install boiler appliances to indicate and control boiler efficiency?

We will all admit that the fundamental reason for the installation of appliances to control the efficiency of the boiler plant is one of economics and that the cost, both initial and maintenance, of any appliances to control efficiency must be more than offset by the saving in dollars and cents by increased efficiency in operation.

I have looked many times for reports on tests to show where the installation had shown a net saving in dollars and cents, but it has always been in a large plant and there never have been any data showing savings in the small plant.

I have a strong feeling that plants with a constant load of 350 to 700 boiler horse power are too small to show any material net saving in dollars and cents by the installation of efficiency control apparatus, but I have never been able to find any real data on the subject.

Mr. J. E. Gibson: You have heard the question of the gentleman from Roanoke. May I ask what the size of your plant is?

Mr. C. E. Moore: Under normal conditions we operate one 350 horse power boiler at a 125 pounds steam pressure with two spare boilers for emergency and standby service, which we have been called upon to use only twice in the last eight years and then for only a short period of time.

Mr. J. E. Gibson: Answering Mr. Moore's question, I should state that seven years ago, when we took over the plant, we had about 6300 consumers and were pumping from 7,000,000 to 7,500,000 gallons per day. Today we have about 9200 consumers and are pumping 5,500,000 gallons per day. This reduction in pumpage is largely attributable to meters. The increased number of consumers is probably due to the fact that we have installed meters on all services and consumers are, therefore, not willing to supply neighbors with water, thereby compelling them to put in individual services.

The old water company had a flat rate system and under this system it was cheaper to let the water run from defective plumbing than to repair the plumbing. With meters, however, this policy has been reversed. We make no adjustments or reduction

in the bill where the water has passed through the meter, whether it has been used legitimately or been allowed to waste from defective fixtures or poor piping underground. Our Commission has stood absolutely back of us in this matter, with the result that we are today getting a much better grade of fixtures and superior plumbing work.

There is a point beyond which you cannot go in mechanical refinement. Mechanical stokers for a plant of your size, I should think, would be a mistake. In fact, I am quite certain of it. We recently put in what are called hand mechanical stokers. They are in reality inclined shaking grates. These grates are within the Dutch Ovens above referred to and, while we are getting better efficiency, I think it is undoubtedly due to the Dutch Ovens rather than to the hand stokers.

Recording gauges on steam and water pressures, thermometers on feed water line to boilers and pyrometer on stack and probably CO_2 recorders and feed water meters, measuring water supply to boilers, are very useful and beneficial. We run a continuous evaporation test and while we have no way of measuring our blow off water from boilers, each day's record is comparable, as the amount of water blown off is practically the same each day. We cannot compare our results with other plants, but we can compare our daily, weekly and monthly record with the previous periods and, like the man playing golf, he knows what he did today and what he did yesterday, and if he did not do as well today as yesterday he is off his game.

SUPERINTENDENTS' QUESTION BOX SERIES[1]

SEASONAL DELIVERY OF WATER WORKS MATERIAL TO AVOID FREIGHT CONGESTION

Mr. J. M. Diven: That question was taken up by request of the United States Chamber of Commerce. They are trying to arrange all freight deliveries to avoid seasonal congestion of freight. Of course, our coal supply, chemicals, etc., must come regularly, but can we not anticipate our needs in cast iron pipe, for instance, which is the bulkiest thing we have, so as to have the deliveries distributed more regularly throughout the year? I tried on several occasions to have the delivery of cast iron pipe made in the winter time. It was awkward to have the pipe scattered around the streets, and it means some additional expense if we have to unload it and cart it to the pipe yard and distribute it again, but I think if you will investigate you will find that there is enough difference in prices of pipe in the winter time over the spring, when everybody wants pipe, to pay this. For the suburban pipe lines and long pipe supply lines you will find winter distribution very much better. I remember recently putting in about 13 miles of 30-inch pipe all cross country. It would have been almost impossible to deliver that pipe in summer when the ground was soft; it had to be drawn across farms and fields, and drawing it in the winter time with snow on the ground was a great saving. The pipe was drawn on sleighs which was very easy, and we could cut across farms without doing any damage whatever, saving considerable in damages to crops that we would have caused in the summer. However, the question is, can we distribute our general delivery so as not to have a rush in the spring of the year? I think it is a question well worthy of consideration.

I presume most of you do get your pipe early in the spring, just about when the frost is out of the ground in the northern part of the country. That does not bother Gibson any, because he can pour the sand out any time, but most of you are in

[1] Presented before the New York Convention, May 23, 1924.

the habit of ordering pipe for delivery in April or May. If everybody did that, there would be a heavy demand for delivery of pipe at that season. I think we ought to consider distributing that demand through the year as much as possible.

Mr. J. E. Gibson: I might state that one of the pipe foundry representatives has stated to me that, due to their agitation for winter purchases, during the past winter they had more orders than they could satisfactorily make and deliver.

Answering Mr. Sterosky's question, I should state that in the matter of bond issues and appropriations, you have to deal with a lawyer and he always depends upon precedents and if precedents set that bond issues must be voted on in November then they cannot be voted on in any other month of the year. Since we opened this subject, Mr. Taylor of the Scranton Gas and Water Company has come into the room, and he has a paper he would like to present to us and, unless there is some objection, we will hear Mr. Taylor's paper at this time.

TASTES DUE TO ALGAE GROWTHS

Mr. Geo. R. Taylor: In February, 1924 we had considerable complaint of taste in the water supplied to the City of Carbondale. Investigation showed that the taste was due to algae in the Brownell Reservoir.

Microscopical examination showed synura and dinobryon present, the former to the extent of 50 standard units and the latter 40 standard units per cubic centimeter. Brownell Reservoir is both a storage and a distributing reservoir with consumers within less than a mile of the intake, so that it would be inadvisable to apply copper sulphate directly in the screen chamber. We decided, therefore, to dissolve the copper sulphate and pump the solution under the ice.

Brownell Reservoir is one mile long with a capacity of 850,000,000 gallons. Some 500 feet from the dam a sand bar runs nearly across the lake, cutting off the lower portion from the rest of the reservoir. We decided to treat this portion of the reservoir in the hope that this would control the taste at least until the ice broke up in the spring. This portion of the lake held about 130,000,000 gallons.

Two and one-half pounds of copper sulphate to one million gallons of water are sufficient to kill dinobryon, but in view of the cold water conditions and to make absolutely certain of our work we used three and a half pounds per million gallons or 450 pounds. We planned to cut holes every twenty-five feet which meant something over four hundred holes. This gave a dose of one pound for each hole. The reservoir was covered with eighteen inches of ice, while temperatures of zero were recorded two mornings during the work, adding to the difficulty of it. We brought up a small portable boiler to furnish stream for dissolving the copper sulphate. This was done by the fireman who measured the copper out in a can holding approximately one pound. The copper was dissolved in wooden pails and were then carried to the sled crew by a second man. A large hand pump with three inch suction and three inch discharge bushed down to an inch was mounted on a two horse sled. Three 45 gallon wooden barrels were used as solution barrels on

the sled. The sled crew consisted of a driver, four men on a pump, the hose man and the foreman. A pailful of the copper sulphate solution was poured into a barrel, the barrel was pumped half full from the reservoir, mixed, and then pumped back under the ice. A twenty-five foot discharge hose was used, attached to a long pole. The hose man distributed the copper as much as possible by working the pole around under the ice in all directions.

Work was started on Tuesday, interrupted on Wednesday by a severe snow storm and finished on Sunday. Labor cost was $316, copper sulphate $27, equipment $30, transportation of supplies and equipment $12, making a total cost of $385. The cost was materially increased by the severe weather and also by the snow and sleet storm of the second day.

Treatment was begun around the screen chamber, working in lines across the reservoir parallel to the dam. By Wednesday the taste in the water in Carbondale had noticeably diminished and by the time the work was completed complaints had practically stopped.

Microscopical examination of samples taken on Friday in the screen chamber showed synura completely killed with dinobryon greatly reduced. Within a week after treatment was commenced complaints from customers had entirely ceased. Samples taken from different portions of the lake inside the sand bar showed synura entirely killed and dinobryon reduced at least 75 per cent over the first analyses. Samples taken above the sand bar where no treatment was applied showed 50 to 60 standard units of dinobryon present but synura only in small numbers, indicating that the troublesome growth had been confined entirely to the lower portion of the reservoir.

Six weeks later when the ice broke up there were again a number of complaints from Carbondale of taste in the water. Microscopical examination of the reservoir water revealed a few fragments that looked like synura, but no living organisms were found. The taste lasted for a few days and then disappeared. Presumably the taste came from the break up of the ice, although a smaller reservoir above Brownell was overflowing at this time and discharging into Brownell reservoir 800 feet from the intake.

From our experience in the treatment of this reservoir we believe it would have given as satisfactory results if only half the distance out from the intake had been treated. The actual distance to be

treated would depend of course upon the volume of water and the daily consumption. It is our belief that treatment for a distance of from 200 to 250 feet from the intake would have held the growth in check until the ice broke up, even though the whole reservoir had been infected with the growth.

The question arises as to the possibility of preventing such winter growths by treatment in the fall before freezing. In the writer's opinion this is entirely possible and should be carried out where tastes frequently develop during the winter time. We had occasion recently to treat under these conditions. The lake is used as a source of ice supply and for several years previously had developed a growth of blue green algae after ice had begun to form. The growth was frozen into the ice, streaking it with green and making it difficult to sell. One pound of copper sulphate per million gallons of water was applied early in December. The ice cut following this treatment was entirely free from algae for the first time in three years. If we had treated our Brownell reservoir in December we would undoubtedly have gone through the winter without any trouble.

The same preventive treatment should be applied to reservoirs which work regularly every summer. If treatment is begun in the spring and repeated every month or two throughout the summer, the majority of even the worst offenders may be controlled.

Mr. S. H. MacKenzie (Southington, Conn.): I should like to inquire if the speaker would recommend the treatment of reservoirs that have given trouble before the trouble occurs; that is, if you have had trouble, say in May, would you recommend treating that reservoir in April, and what dose would you recommend.

Mr. G. R. Taylor: So far as treating it to prevent summer growth, if your State Board of Health is entirely willing, I personally would recommend it, especially if your algae growth has been troublesome in the way of controlling, after it gets thoroughly started. There are some types of summer growth and some waters which, owing to the chemical composition, give very nasty appearance on treating with copper sulphate, if the treatment has been delayed too long, you get decomposition of the algae, which has proceeded to a considerable extent, and sometimes you get a precipitated copper carbonate suspended at that reservoir, making a very disagreeable

effect. I cannot see any difference, from the health standpoint, in applying the copper sulphate just before your reservoir begins to work, I mean one of these reservoirs that works every year, and applying it a month later after the algae growth is well started. I feel sure that ordinarily such application would control the growth. There are some reservoirs like the old Springfield, Mass. reservoir, where the seeding of those reservoirs was so intense that it was impossible to control it by any method of copper sulphate treatment.

Mr. Dugger (Newport News, Va.): Along that same line, we have tried the same treatment, two or three treatments a year, and we find that it will not stop it altogether, but we do find it relieved to a great extent. As the speaker just said, we do find the suspension after the treatment in the warmer season. We use about three treatments a year. Just before I left we had finished our first treatment and we started again about the first of July and again the latter part of September.

Mr. E. L. Filby: Algae troubles appeared in the open reservoirs of the City of Greenwood, S. C. This supply is from deep wells by air lift. The superintendent, Mr. A. J. Sproles, requested the Department of Agriculture to investigate the growth and they advised copper sulphate treatment. Mr. Sproles put in the copper sulphate as directed and killed all the goldfish in town. He said that the ladies raised so much Cain about the fish that, rather than repeat the dosage, he has let the algae conditions continue. You have to watch your step or the people may complain from a condition other than taste and odor.

Mr. J. E. Gibson: We use copper sulphate continuously throughout the year, except during the colder months—November, December, January, and February—not once or twice a month, but every day. We have found that this is about the only way that we can control the situation. We have analyzed our water repeatedly, but have never been able to find a trace of copper in the filtered water. We use about 40 pounds of copper per day in our large reservoir. Our method, I think, is rather crude—that of trailing it from the stern of a row boat. I have thought seriously of trying to put in some form of spray or sprinkler system to cover the area

in the immediate vicinity of the intake. I believe some such device would effect a material saving in copper sulphate and would certainly increase efficiency.

In addition to the copper sulphate in our large storage reservoir, we use during a portion of the year about 10 pounds per day in our sedimentation basin of 10 million gallons capacity, and we also use during the algae growing period about five pounds per day at the outlet of our effluent channel. We find that by the use of this second dose at the effluent we can control and practically stop the growth of algae in our clear water basin. For aesthetic reasons this is very desirable as the clear water basin is open and it is one of the attractive spots about the pumping station for visitors.

FLUSHOMETER WATER CLOSETS

Mr. J. M. Diven: I think this a question we ought to take up and take up right now. This is something new, and as I see it, something that is going to cause us a lot of trouble if we do not solve the problem now. The architects are specifying them because they look pretty and there is no tank in the way. I fail to see any other advantage in the form of closet. But they are coming in, they are asking for large size services, even for private houses; they are asking as high as an inch and a half to supply an ordinary dwelling. Mr. Gwinn last year told of his experience in using an expansion tank in the cellar of a house, I think he said he used an ordinary house boiler. We ought to put ourselves on record either as demanding the use of an expansion tank or opposing the use of flushometer closets. We do not want to be called on to put in one to two inch services for a private house to supply one water closet. The sooner we get on record and devise some way of taking care of these, the better, and if we cannot do it by discussion here, I would suggest that a Committee be appointed to study this matter and to bring before the membership some plan for taking care of them before they spread. After they come into general use, we will be helpless. We cannot say to people "You must take these out," but when they make application for installing one, if we have some plan for an expansion tank or some way of taking care of them satisfactorily to us, the matter may be controlled. It is one of those things that will spread and spread rapidly and will soon be beyond our control. Now is the time for us to consider this question. If we cannot do it by discussion here, we ought to have a strong committee to work it and to formulate the rules which we can afterwards adopt and try to live up to.

Mr. D. H. Heffernan: The question of flushometers is one that is giving the superintendent considerable trouble. Regarding the recommendation about putting in the expansion tank, I do not think there is any need of 30 or 40 gallons in the ordinary residence. They

can put in something about 12 or 15 gallons, and I think this would be ample to take care of the consumption of those closets without interfering with the pressure to the other fixtures.

Answering Mr. Diven's question, I have known of several successful flushometer installations in houses when the additional expense of a larger service pipe was not deemed advisable, which were successful through the installation of a ten-gallon tank. The danger of water hammer may be eliminated by using a tank of the closed type, making both connections at the bottom of the tank to permit provision for a fair-sized cushion of air at the top. The tank should be set conveniently with a direct run to the flushometer.

It is my opinion that an air chamber consisting of a three-foot upright of pipe one size larger than the main house supply should be installed in the leader of all services, thus further tending to eliminate water hammer.

I am fully in accord with a previous speaker's recommendations to the chair that, if all the salient pertaining to flushometer installation are not clearly brought out in this discussion, a committee be appointed to given this matter further study from the points of view of the plumber and the water works superintendent.

Mr. Moseley: It seems to me that some of you gentlemen are alarmed over a situation or rather the chance of a future situation, that is not in the least alarming. There are very few cases where the need for larger taps occurs, particularly in places in which the water pressure is at all high. This is certainly not a case for snap judgment, and it may be, as has already been suggested a case for committee action.

Mr. J. M. Diven: Why not make this as a motion?

Mr. Moseley: Perhaps it would be better for an older member of this Association to make such a motion.

Mr. J. E. Gibson: This is a very important question and if Mr. Moseley can throw any additional light on it I will be very pleased to hear him. We do not have the trouble because of our variable minimum depending on the size of the service. When the architect specifies flushometer closets with $1\frac{1}{2}$-inch service pipe and we

tell the owner that is is going to cost him $12.50 per quarter if he puts in that size service, he quickly decides the matter in favor of the old style closet. Somebody in discussing a similar question in the New England Water Works Association hit the nail on the head when he said that the low tank was low in other things besides elevation. We have a great deal of trouble with the low tank closet and comparatively little with the old high style tank.

Mr. D. H. Heffernan: I should like to ask Mr. Moseley if he has run across any trouble.

Mr. Moseley: I know of no case.

Mr. Heffernan: Has it been a fact?

Mr. Moseley: So far as I know it has never occurred.

Mr. Heffernan: It has occurred, but they have made an improvement in the valve.

Mr. Heffernan: I refer to direct pressure.

Mr. J. E. Gibson: Is there any further discussion? Well, Mr. Moseley, suppose you make that motion and maybe we will get some discussion on the motion.

Mr. Moseley: I would like some suggestion. Either a committee could be appointed or discussions could be handled through the Secretary's office.

Mr. Diven: That is about what we have done, what we did last year and again this year, asking for discussion, but we are not getting much. I believe the appointment of a definite committee to study the question of the use of flushometers carefully and report to the convention would be more apt to bring about something. The President has authority to appoint any special committees.

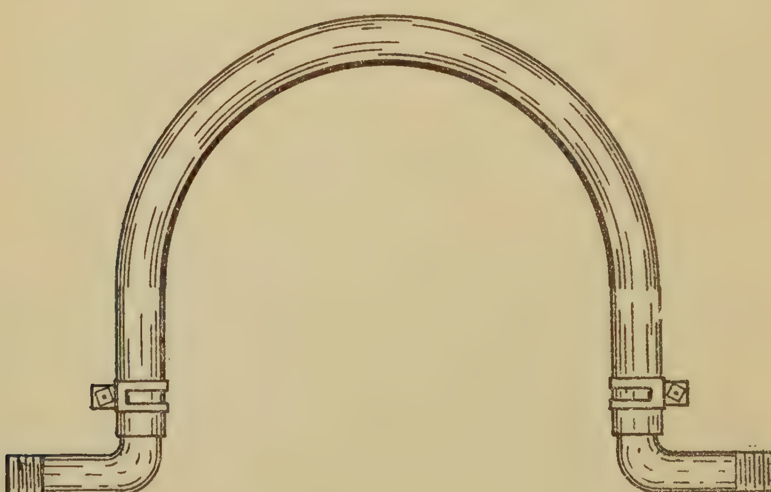
Mr. Moseley: I move that the President of this Association be requested to appoint a Committee on the Use of Flushometers.

This motion was seconded by Mr. Diven and unanimously adopted.

HELPFUL TOOLS IN REMOVING METERS

Mr. J. M. Diven: In this connection, a member, Mr. C. E. Abbott, of Tuscaloosa, Ala., has made a drawing of a little device he is using, and has sent me the drawing. You have all had trouble in replacing meters or taking meters out to repair them and putting the replacer in. Mr. Abbott has devised this; this is the two trestles which replace and fasten to each of the nipples; this is a heavy three-quarter inch hose, something that is flexible, and he says he found it very convenient. I think it is a mighty good suggestion and one that is well worth while. It is an appliance which is worth while for a water works superintendent, and I think that the publication of that drawing with a brief description of its operation would be of interest to a good many of the members.

Mr. C. E. Abbott: The apparatus consists of two street ells, short nipple and piece of hose about 18 inches long. This makes it very easy to remove $\frac{5}{8}$, $\frac{3}{4}$, and 1 inch meters as the hose will permit the replacing of gaskets without any delay or trouble. We have a number of these and our meter men can get any number at one trip. The device is shown in figure 1.



For Removing Meters for Cleaning and Repairing

Fig. 1.

Mr. William H. Buck: In reference to the tool of which Mr. Diven spoke, I had occasion to test 300 meters during the month of January, which is a ruling of the Utilities Commission of the State of New Jersey, and used principally the rams-horn meter yoke, to simplify the matter and not have to replace the meter with another while it is being tested. We made fillers the length of the meter and just clamped them in while we had that meter out; it was taken out today and replaced tomorrow; just about so many at every test, and then replaced them the following day. That expedited the work very materially where we had the meters put in with the regular meter coupling, we substituted a filler for that purpose. That may be an old story to most of you gentlemen, but that has been my experience and it is a very good proposition, or seems so to me as a new man with meters. We just started to install meters a few years go, and this was my first season of testing meters.

A Member: I would like to inquire what those are.

Mr. Buck: Ordinary inch pipe. The meter yoke that I use is the Ford meter yoke, the rams-horn, the five-eighth meter; I think the over all distance is $7\frac{1}{4}$ inches; cut a thread on the end where you want to couple it up with a coupling; if you want to couple it up with a meter yoke, all you have to do is to score it with a pipe cutter and take a hacksaw, so that you have a face there, because there is a washer in each one and it is drawn together with a drain bowl, perfectly tight. A man can take out a meter and put the filler in, all in three minutes.

A Member: I have done that, but the objection I found to it was that the pipe seemed to be thinner on the ends than the meter, and sometimes than the coupling.

Mr. Buck: That is after you cut a thread. With the yoke you have no thread at all, but with the coupling you have a thread. The better way is to cut off the pipe with a pipe cutter, to burr it to a certain extent, which you can face off with a file and make it a flush surface. If you just score it with a pipe cutter, which would give you a perfectly straight line around the pipe, and follow it up with a hacksaw, you have a blunt face which will readily unite with the washer you have in there and make a perfectly tight joint.

Mr. Bowman (Iowa): I had the same experience as the former speaker with reference to the pipe. If you take a square inch pipe cutter, cutting out a small ream, eighth of an inch wide all the way around, you can cut it as well as with the ordinary roller cutter, and cut it square; you do not require a hacksaw.

Mr. Wm. J. Willson: The taking out of meters and putting them in, of putting in this temporary connection in places where you have to go three or four miles from your shop to put in a meter, does not seem to me to be very economical to have to go back the second time to put in a meter where it can be changed from one meter to the other; I do not think that would be economically operative.

Mr. Buck: In reply to that, I should like to make this statement, that that would very much complicate the bookkeeping; that is, at least by the method I am following in setting meters. I provide every meter with a serial number which is recorded on our books; that is, we know there is number ten meter at number two twenty Morgan Avenue, for instance; that always remains at 220 Morgan Avenue. If the meter has to be changed, that serial number is taken off and put into another, but the manufacturers number is also on the record. That keeps a record of where these meters are and how long their life is without making the bookkeeping more intricate for the office than in the first place. I considered that very thing myself, but found it would be a far more tedious proposition to make new records and mix up the bookkeeping in the office to such an extent that it would take a greater force of bookkeepers to keep things straight than it would be worth.

Mr. D. H. Heffernan: I want to ask Mr. Buck if the labor and expense of removing, testing and replacing water meters every three years, is justified in his opinion, and if the inaccuracy of the meter after these three years of service warrants it.

We try to make a practice of testing meters every five years. In our case, however, to save the expense of replacing the meter on the same service from which it was removed, at the time it is taken out for test, it is replaced with another and that meter is allowed to remain on that same service until it is removed for cause. The extra bookkeeping entailed is considerably less trouble than the extra labor involved in going back to the same service a second

time. We have been 100 per cent metered for 34 years, and my experience has been that the gain in revenue from testing more frequently than every five or six years is more than offset by the cost of such testing.

Mr. Buck: The Utilities Commission of the State of New Jersey dictates that course to us and we have to follow orders. That is the only explanation I can give.

Mr. J. E. Gibson: I think that answer can be summed up in the words that some of our utilities commissioners have not had 34 years experience with water meters.

Mr. Buck: That is it exactly—or with anything else.

PIPE JOINT MATERIALS

Mr. Sterosky (Port Huron, Mich.): I should like to ask a question in regard to results secured with leadite, lead or cement for making pipe joints. I have used leadite as an experiment and did not have much success. Perhaps I did not go at it right.

Mr. W. H. Buck: The gentlemen is striking a very vital point, Mr. President, as regards leadite. I am a great friend of leadite. I have used it, as near as my memory serves me, for about 18 years. I am probably one of the original people to use it. I have put in a good many miles of pipe, in fact the cement or concrete pipe was probably the original cause of my using it, as it has a pressed steel belled spigot on each side of the reinforcing jacket, and I was afraid on light pipe such as four and six inch pipe, to drive it with lead, so I thought I would try leadite. The first lot I put in was about 1800 feet of four inch. When I put the test on we had a little porous sweat showing at the gate. I have put in since probably ten miles of 4 to 8 inch pipe, both cast iron and cement pipe. It may sound a little fishy, but I have only had one joint come out. That was poorly made in quicksand or a quicksand bottom, and the only reason for that joint being bad was that some dirt got into the joint.

There are principally two things to be considered in using leadite; the first is cleanliness and the second is to have the leadite of the right temperature when it is poured. For any one to expect to melt leadite to the proper temperature with wood charcoal or any such method as that, I think is an absolute mistake, because we cannot control the heat quickly enough. The only proper method, in my opinion, is the gasoline furnace which you can buy from the water works supply people or from the Leadite Company for a nominal cost. Another important matter is the jute packing that you use, which should be as dry as possibly and contain as little oil as possible. It should be driven home the same as you would oakum for a lead joint. If you want to pour a high joint, for instance, put your runner around the joint and there is a funnel that I am using,

about two inches at the mouth and two inches and a half at the top and an inch and a half at the bottom. That is placed in a V shaped clamp at the runner and banked up with soft clay. The joint is poured high because the leadite will core so that there will be a solid mass of leadite in there. If you follow those instructions strictly, you will have no cause for complaint. The joint may sweat for a little bit, but in these 48 years it is just as tight as ever and in fact it becomes tighter. It improves with age, as we have seen, and my experience with the leadite joint is that it is best. When the caulker strikes the last blow, leadite will give, but will not come back. If you have any settling, the joint will give there. If you have a leak, there is no other way to get in it unless you go down and re-drive it.

Mr. W. J. Willson: This is very interesting to me, as I have not been an advocate of leadite, although the leadite representatives have followed me up pretty closely. I want to relate a little experience I had here about six weeks ago, in making an installation of some 12 inch pipe in a plant where seventeen 12 inch joints were necessary. The recommendation to this power plant was to use lead. The contractor who had this work in charge was persuaded to use leadite. He had a representative from the leadite people who came there and put in the joints. After the joints had been put in and the pressure turned on, 110 pounds, 11 of the 17 joints were found leaking. They tried to caulk them off, remaining there 4 days. The engineer of the plant issued an order finally to remove all the leadite and put in lead; therefore, I still contend that the use of lead is preferable to leadite.

Mr. S. H. Taylor (New Bedford, Mass.): About 1910 the New Bedford Water Works made a few joints with leadite which have been under careful observation since that time. In the spring of 1920, we made some more extensive experiments with leadite and lead hydrotite. These are described fully in the journal of the New England Water Works Association, Vol. XXXVI, No. 3. The results of these tests were so satisfactory that we have been using leadite almost exclusively since then, laying about 24 miles of pipe, from 2 to 48 inches in size. We find that this use results in a considerable saving in both the cost of material and labor, especially in wet places where the digging is very hard, as no bell holes are required.

As has been stated it is essential to have the bell and spigot ends clean. This is easily accomplished by wiping with waste or bagging.

The jute should be of best quality and free from oil. We have found that it pays to use braided jute such as is on exhibition at the Leadite Company's booth. The extra cost per pound is more than offset by the saving in labor and elimination of waste. This braided jute can easily be cut to the exact length required.

Our experience with leadite has been very favorable. We are now using it, and unless something unforseen happens we will continue to use it.

Mr. J. M. Diven: I think as Mr. Buck said, it all depends on the right temperature. One of my experiences, after being a skeptic for a long time, I think the last job I did was to put on a Smith tapping sleeve, 30 by double 8 and make 8-inch taps. The temperature was below 50 and water going through a 30 inch pipe at a velocity of 4 feet a second. The work was absolutely successful, no sign of a leak. That was done about 5 years ago and still holds.

LOCATING LEAKS

Mr. Sterosky: In regard to locating a leak in cold weather under the pavement, last winter I had a little experience with a service pipe that froze and burst under a brick pavement. The difficulty was to locate it, as the water came out about 25 or 30 feet away from where the break was. I had my shutoff key with me and I put it on the pavement and kept listening, and finally I found out where the pipe was broken and located it without much expense.

Mr. L. E. Moore: There was an article published in the Journal (see Journal, September, 1923, page 850) a short time ago on the use of the geophone, and from a number of inquiries we had as to the result of that, I feel that it must be something entirely new in the field. A great many people seem to know nothing about it. The instrument is composed of two clubs they use just like the pair you used to play hockey on the ice with. It has a thin sheet steel diaphragm with a lead weight and a rubber tube leads from each disc to an ear piece. The method of using this instrument to determine leaks is to place it on the ground or pavement or whatever it is, applying the two ear tubes in your ears, and if you are anywhere near a leak, you will get a sound. The volume of that sound is determined by the two discs; that is the reason for having two; the louder, of course, is nearer the leak.

I give you my own personal experience with it, because I do not suppose it will sound the same to any two men and you can take my experience for what you think it is worth. The instrument was sent to us as a good instrument, and I was told to use it. I knew nothing about it or how it was made, but at the time I received it we had a leak on a main under a paved street. It had a 3 or 4 inch concrete sub-base with two inch sand cushion and a grouted brick paving over that. We knew that in the stretch of about 550 feet there was a leak; where it was we did not know, but we knew there was a leak. I experimented around our yard with this new geophone and could get all kinds of noises. I could not made heads

or tails out of it, so I decided that to make the test absolutely positive I must wait until the early hours of the morning when there were no foreign noises about. I started out after the traffic had gone from the streets and heard a very peculiar noise. Then I would not hear it; then I would hear it again and then I would not. I was about to throw the thing away and say it was no good. The point I want to make is that this instrument was very sensitive and you have got to get acquainted with it. You will probably fail the first time you use it, because when I was about to give the job up I found there was a city street sweeper about a block away that was making the intermittent noise, so I waited until he got the street cleaned and had gone to bed before I started in, and in just about 15 minutes I decided where the leak was and sent my men there the next morning and I missed it about four inches. That was the first experience I had with it.

Mr. J. E. Gibson: How deep was that leak?

Mr. Moore: About three feet in the ground, and it was at a corporation cock, just a little fine stream where the reducing elbows on the corporation cock had worn the fitting away. We had another experience under an entirely concrete road in much the same manner. Before that time we had gotten acquainted with the geophone and understood it and were able to locate that leak even while traffic was going on. On another occasion, the gas people reported to us a leak on a dirt street. They had occasion to make a cap on their main and they had to keep a ditch pump going in their ditch all the time. We covered about 500 feet of road and were able to locate no leak, no sound of any kind, but a further investigation showed that the water that the gas company was up against was ordinary surface water, clay soil, and that water dried up in about two weeks and there was no water there. It has been our experience that the geophone is an instrument without which you cannot get along. We now have two of them. We have located trouble on our consumers property and we have located many leaks in paved streets. As we have to pay for all street replacement, it means a big saving to us. We feel that the first leak we located saved us the cost of the instrument; but if you can profit by my experience, I do want to caution you to be very careful and get thoroughly familiar with it, because you will get everything that

is going, a man walking on the street, cars running on the street, you will hear every vibration there is, and you must become acquainted with it to know that you are absolutely right.

Mr. Franklin Henshaw: I have had a little experience with the geophone. In the literature the company sends out, and the last speaker mentioned it also, the direction of the sound, that is, the direction of the leak from the location of your instrument is determined by the sound which comes to either ear. Now with a man who hears equally well in both ears, it works very nicely. I happen to have quite a little difference in mine; I hear much more acutely with my right ear than my left one, and I was fooled at first, until I learned the trick, after listening and getting the sound, of simply removing and changing the ear phones; then if I got a louder noise from one direction the same as before, I knew it was in that direction; if not, I went the other way. It does work out excellently if you observe a few of those little precautions. The difficulty about using the instrument in traffic on paved roads is great, just as it is with a wireless leak locator or any of those sound instruments, because you can hear an automobile further away than you can see it, and unless you do a great deal of work at night, you are apt to be deceived, until you become acquainted with the peculiarities of the instrument.

Mr. D. H. Heffernan: My experience with these useful instruments might be of some value to the members. The Darley machine, I purchased several years ago, and had such good luck with it that I wrote a paper on my experiences and presented it to the New England Water Works Association.

This machine consists of a special microphone detector mounted on a brass plate having four legs. This detector is connected with an amplifier battery and sensitive wireless ear receivers.

My first experience with this machine is interesting. One of our local plumbers called me up one day and said that there was a bad leak on a large estate where he was working, but that no sign of the leak was apparent anywhere. Here was the opportunity I was looking for. So I took the leak locator to the estate to give it its first trial. After locating the pipe with the pipe locator, I started in with with the leak locator and made several tests along the pipe, which was 500 feet long. After about an hour I designated to the

laborer where I judged the leak to be and the next day he dug at the point indicated and came directly on top of the leak.

A couple of months ago I was asked to witness a test in a neighboring city of this instrument, by the geophone salesman who had been trying to interest me in his product for some time past. Daytime noises interfered somewhat with the best operation of the instrument, but at the point where we came to the conclusion the leak was, an excavation proved a leak to be. Several other leaks were also found in the immediate vicinity. Further tests have convinced me that the geophone is an accurate instrument.

My recommendation to you fellow-members is to purchase either one or the other. Practice with it on a floor, beneath which is a pipe carrying water, and make similar tests out-of-doors. Become accustomed to the various noises transmitted by the locator or geophone and when you are able to recognize the sound produced by a leak, use it with confidence, but, whichever you choose, do not be without an efficient device for locating leaks.

Mr. J. E. Gibson: We have used the pipe locator at Charleston. We tried the Darley Electric Leak Locator, but I guess we have too many night hawks in Charleston as we could never get traffic quiet enough actually to determine the location of the leak, and about the time traffic had quieted down someone in the neighborhood would draw water and start the meter going. The pipe locator is of the wireless type. The two ends of electric current are connected to the service pipe, and in this circuit there is a vibrating instrument which set up magnetic waves radiating from the pipe line. Then with a coil connected to telephone ear pieces you can follow these waves and when directly over the pipe, the field being equally strong, the buzzing in the ear pieces stops. It is a very satisfactory machine. It is made by the W. S. Darley and Company of Chicago, Ill.

Mr. Moore: There is one question I would like to ask, if there is anybody who has an instrument that locates a pipe that is dead-ended? I can give you a concrete illustration of what I mean. If you are forced to install a sub-service on account of street improvements, and lose it, how are you going to find out without just digging for it? There was an article in one of the magazines, I have forgotten the name of the concern, but somewhere out in San Fran-

cisco or Los Angeles, that advertised a machine that would locate a dead ended pipe, and five minutes after I saw it I had a letter on the way for one. They advertised to send it on trial. I tried it but could not make it work. If there is anybody else who has tried it and it has been successful, I would certainly like to hear about it.

Mr. Weir (University City, Mo.): I find that I can locate a stub end pipe by using the ordinary "wireless pipe locater." To do this one lead from the coil box is attached as usual to a faucet or other connection to the main. The other lead is connected to a steel pin, or when this is not available to a pick head or simply stuck into the ground within fifty feet or so of the main, on the other side of the point where the main is to be located.

By grounding one of the leads in this manner the signals will be received practically as loud as when two connections to the main are made, and then the pipe can be traced in the usual manner.

Mr. J. E. Gibson: I should think that would locate the stub end.

RESETTING METERS AND METER LOCATION RECORDS

Mr. H. B. Foote: I think it is a matter of great interest in the economical operation of a water company as to whether the cost of one feature offsets the cost of the other. Where you have the manufacturer's number of your meter and the serial number, you have the same number on the consumers sheet, and if you have the retail record you have the numbers there. If you also have an individual record of the meters kept according to meter numbers, you have to change all those numbers on your meter readers' sheets, consumers' sheets and repair record, and then you have to change the address or location of meter on your meter record. There are four opportunities of error. If you take the meter out and substitute a meter, is it not cheaper in the end and more reliable to put in a dutchman or one temporarily and then put the same meter back? I should like to ask the gentleman who used the method of putting in a new meter in place of the old one and leaving it after they had a complete record of their meter, how they find the cost compares to the cost of the other method?

Mr. J. E. Gibson: We have to move meters so much at Charleston it has ceased to be any trouble. One of our oldest employees says that when our people cannot move any other place they will move from the downstairs flat to the upstairs flat. This statement is probably exaggerated for we have some customers that have lived in the same house all of their lives. I have in mind one of our old Charlestonian ladies who was born, married and buried her husband from the house she is now living in. She is about ninety years of age.

If we tried to keep the same meter for the same premise we would probably have some 700 or 800 meters at this moment tied up on unused or idle services. We find that it pays, if the premise is vacant more than two weeks, to remove the meter and place it on an active service. Incidentally, we often find that, in the interval since the last tenant has moved out, someone has moved and proceeded to turn the water on without authority, and this constant

moving and taking out of meters saves us a good many dollars' worth of water for this reason alone.

Answering Mr. Foote's question, I would state that we have had very little trouble in checking up on our meters. Once in a great while we get a number mixed up and have difficulty in locating the meter, but this always shows up at the next meter reading as our meter readers are cautioned to check numbers and readings. Invariably we find this is due to transposition of figures in copying the records.

Mr. J. G. Valentino: The property owner is responsible for water rents in Savannah. We set the meter on the piece of property and unless he comes down and has the water cock disconnected, we leave it there and he pays his ninety cents a month right along because it costs him $1.50 to get his water turned on again if it is turned off. Unless he thinks the place is going to be vacant for some time, he will leave the meter there when they move. When we make repairs, we have couplings the exact length of all pipes and makes of meters. I have 13 different manufactures of meters and many different types of each of them, so we have quite an assortment of pipe supplies and whenever a meter is reported to me, my man goes out, takes the leader out and sticks a nipple in and when the meter is repaired he goes back and takes the nipple out. I can keep my records better that way than I can by changing meters.

Mr. H. T. Gidley: I agree with Mr. Foote on the complication it makes when you shift meters around. We put one meter in a place in Fairhaven, Mass. and, of course, we have three or four different cards with that meter number on and the address of the place where it is put in. Where you have many thousands of meters, it seems to me that you would have to have a big staff of bookkeepers. Our water acts on meters, though in some cases the meters stay quite a time and we do not take them out oftener than necessary. We do not take them out in three years unless we have to, but we have one meter and keep it in one place until we absolutely have to change it for another meter. When we take a meter out for repairs or adjustment, we put in a blank nipple and that meter goes back to the same place. That seems to me is the best plan.

Mr. F. Henshaw: I am using a small portable tester in Scarsdale, N. Y. I attach the tester to the meter and let the water run into a washtub and you can make a very accurate preliminary test. It requires only a few minutes to connect up such a piece of apparatus, and a meter seldom has to be taken out of the house at all unless it is in bad shape. If it is found by the test as shown by the portable meter, that the meter is in bad shape and needs repair, then it has to go to the shop for repair, but in making a periodic test through a community, it proved to be of great advantage to us to use the small portable test meter. The meter does not have to be entirely removed from the house and taken in for testing purposes. It saves a lot of time and a lot of bother.

Mr. J. E. Gibson: Mr. Valentino is a strong advocate of universal system of sizes and dimensions of meters.

Mr. J. G. Valentino: I will say this, that we have, I think about 8 or 10 thousand services on meters and about 2800 letters, in the service, and in a recent letting down, I thought I would check over and see how many different makes we did have. We had 13 different makes of meters. Of some we only had one meter; of some we had three or four and in others it ran up to 10 or 12. I noticed that in some makes there were at least three different models. Unfortunately the water department has been more or less of a political plum down there for a number of years and I think everybody who came along thought he would try out something new. It is true the little time I have been there I have been working toward the end of trying to standardize on something, although I have not had much success with it so far. I will say this much, I am an advocate of a first class meter, regardless of cost.

AUTOMATIC SPRINKLER CHARGES AND REGULATIONS

Mr. H. A. Burnham: I have not prepared a paper on this matter, but we all know that the Association has recently manifested a new interest in fire protection matters, especially in connection with activities of the National Fire Protection Association. I thought it might be of interest for the members to see some of the reports that Association has put out. I have the pleasure of being Chairman of the Committee on Private Fire Supplies from Public Mains, and we have in charge the consideration of this subject in four sections. We are not progressing very fast with it. The first section is the matter of making charges for sprinkler service. The second section will be on the matter of waste. The third will deal with cross connections and the last with connecting high pressure fire systems to automatic sprinklers.

In the program this afternoon we have as one of the topics for discussion, the charges for automatic sprinkler service. If we are to encourage fire protection, the charge will be made as slow as it can be consistently. The Inspection Department of the Factory Insurance Companies has gone into the matter extensively and has looked up the general practice today in the matter of charges. We sent out a questionnaire about a year ago to find out what the general practice is, and the substance of it was that more than half the water departments, both private and municipal included, make no charge at all for strictly automatic sprinkler service. Now you may wonder where they get their revenue. There has been no standard practice in establishing a proper basis for charge for sprinkler service, and it is interesting to note that, if you consider the municipal departments alone, there are 66 per cent, or two-thirds, making no charge, and of the private companies 21 per cent make no charge, that is, about one-fifth. Most of those private companies making no charge are in the States of New York, Massachusetts and Connecticut.

There were considerable data published on this matter in one of the recent numbers of *Fire and Water Engineering*, so I do not need to go into the details thereon, but this thing did stand out, that there

seemed to be no fair and definite basis on which these charges were made. About a third of all that reported made the charges on the basis of the number of automatic sprinklers they had in the plant; another third made a flat charge on the size of the connection; and another third made a charge dependent somewhat on various combinations such as number of sprinklers, number of hydrants and size of the connection. In order to determine where the proper basis might be found, I just jotted down these few notes regarding the matter, which may be of interest to you.

If the charge is based on the number of sprinklers, a penalty is thus imposed on the most effective means of fire protection known, and installations of sprinkler equipments are discouraged. It means the more sprinkler heads a property owner has, the more he must pay the water department for fire proection. If his entire property is sprinklered the number of sprinkler heads is proportional to the floor area and so approximately proportional to the value of the property, but as the usual property tax is also based on the value of the property, the placing of a special fire protection tax on this same basis appears like double taxation. This apparent injustice would seem further pronounced in cases where municipalities may compel by law the installation of sprinklers in places where people may assemble, such as theatres, schools, factories or stores.

As to the use of the number of hydrants as a basis for charge, this practice is doubtless the result of a long standing custom of making charges for fire service to municipalities where a part of the cost of the general fire protection is that of maintaining the hydrants, and as this part of the cost is proportional to the number of hydrants, this basis is fair for this part, as long as the water department provides and maintains the hydrants. Where the hydrants of the private fire equipments are owned and maintained privately, however, as is generally the case, a charge by the municipality for maintaining them is of course not fair.

Eliminating as unsound the practice of basing a charge on the number of sprinklers or hydrants, the remaining prevailing basis is that of the size of the connection. This basis appears the most reasonable. The cost of the pipe and the controlling devices on it, which may be owned and maintained by the municipality, between the street main and the protected property is proportional to its size and a nominal charge to cover interest, depreciation and main-

tenance of these is just. Such a charge is not so large as to be a deterrent to the installation of adequate protection of life and property through automatic sprinklers.

The question may arise as to why, in this argument, use is not made of the delivering capacity of the outlets afforded by the hydrants and sprinklers. The answer is that in the first determination of the capacity requirement for general fire service, it is assumed and expected that the maximum delivery capacity of the public system as a whole will be used if necessary to extinguish any fire whether in sprinklered or unsprinklered property. No public system could possibly supply water at serviceable pressure to all the hydrant and sprinkler outlets on it, and therein lies the differences between the demands of fire service and of industrial service. In the latter the system must continually supply water to all its outlets. In the fire service this is impossible.

Mr. J. E. Gibson: We make a flat charge dependent on the size of the service, the maximum being $50.00 for a 6 inch service. We refuse to put in services larger than 6 inches and if, in our judgment, the property needs a larger service we insist upon them taking two services of not greater than 6 inches in diameter, from independent mains so that in case of difficulty or breakage in this service line within the building, the entire community is not inconvenienced.

Mr. J. G. Valentino: Do you make any higher charge or additional charge for fire protection on property outside the coporate limits?

Mr. J. E. Gibson: We will not permit any other service to be taken off of the sprinkler system, and we have found that without regard to how responsible or upright the owner of the property may be, if we permit him to put fire plugs or hose nozzles or any other means of getting water out of the sprinkler system other than through the sprinkler head, sooner or later some employee will begin to take water out of these openings without the owner's knowledge.

Our rate for domestic and fire protection outside of the corporate limits is the same as that in the corporate limits.

Mr. J. G. Valentino: Our rules are that outside the city limits, where they do not pay city taxes, we require them to meter fire

lines, but for buildings inside, like warehouses, etc., where it is a sprinkler system alone, in other words where you have a 6- or 8-inch line going in and nothing but sprinkler heads on it with no hydrants, we do not make any charge, but, if we put one hydrant on, he has to put a meter on. I was going down the principal street of the town not long ago and happened to turn off into a side street, and going by a furniture store I found a man using two big fire hose. I asked the man what he was doing. He said he was keeping the dust down. I said "Is this line on a meter?" He said "No. I am just keeping the dust down; I get out every morning and sprinkle the street here."

Mr. H. A. Burnham: The speaker has brought up one of the most troublesome questions we have had to deal with in private fire protection. A great many of the manufacturing towns and cities have factories which have more or less yard room; some of them have a good deal of yard room and have to have an extensive outside pipe system from which the sprinkler supplies for the various buildings are taken, and we have found, mostly in the northern and in some central cities, that the most practical way to handle that question of taking water without authority is to have an understanding with the water department, backed by a contract or a bond, that it shall not be done and then in order to check up on those who do not know any better, have the hydrants and drains sealed and make a charge to the user for resealing them. The gentleman who spoke says that does not work well in his city, but there are a great many cities where it does work well. I think there are more doing it in that way than by putting in meters. There are very few meters acceptable for fire service. In our laboratory in Boston we have recently conducted experiments on the flow through a small meter around a weighted check valve and that promises to do very nicely if you do not want to measure the water for fire purposes. We find by making a check valve with a specially large bonnet that will allow a heavy chunk of lead on the clapper, you can by-pass that with a two inch meter and register accurately up to 25 gallons a minute. That is an excellent detector, but it will not do if you care to measure fire flows.

Mr. Foote: I would like to ask the writer of the paper on this question whether the underwriters are advocating that it is not

proper to make a flat rate charge on the fire connection for a sprinkler system based on the size of the main; they contend that that is reducing the quantity of water you have to have available for fire service because the sprinkler puts out the fire and obviates the necessity for the use of a large quantity of water, and they are advocating that a charge shall not be applied and are stirring up a considerable agitation among consumers.

Mr. H. A. Burnham: If you have one of those reports in your hand you will see on the second page under "Findings of Commissions" in regard to taxation applied that way in the case of a private water company that, in the State of Pennsylvania, they say that to collect a charge for strictly fire service would amount to double taxation.

Mr. MacKenzie: There are very few municipal departments or private companies that receive the revenue they should from the fire protection end of their plants.

The idea of the insurance companies, that there should be no extra charge for hydrants and sprinklers in manufacturing plants, is fine, if the cost of the service was covered by the amount paid by most municipalities. The manufacturers are large tax-payers and no doubt are entitled to the service and I for one should like to see public sentiment educated to the point that would permit public funds to be used for the entire fire protection cost the same as for police and fire department charges. I think the insurance companies can be of great assistance in helping to create the public sentiment desired, if, when they are making reports on the inspection of the various communities, they would make mention of the value of adequate fire protection and note that the amount being paid by the municipality does not cover the cost of service being rendered and possibly mention some amount, if they have the information which would warrant them in so doing, or, if they can not do that, give about the percentage of income of the water plant that should be received from fire protection.

I have a newspaper clipping before me in regard to hydrant rentals at South Manchester, Conn., which states that the Fire District has just voted to pay the water company about $12,000 per year for two hundred and one hydrants, for a term of twenty-five years. If the facts are reported correctly that water company will be receiving more nearly a just return for fire protection than most companies or municipalities I am acquainted with.

THE SIZE OF FIRE SERVICES

Mr. H. A. Burnham: That is really one of the larger topics our Committee is considering in the National Fire Protection Association, and I can furnish a little more data on that question regarding the general practice all over the country. The matter of water waste through bleeding the system at the time of fire has been the subject of study by water works engineers for many years. In the work of factory fire protection as practiced in our field, we have practically established that such waste is better guarded by proper location of controlling valves than by restriction of the pipe size.

A few cities, appreciating the difficulty of obtaining control which would be absolutely certain under any conditions, have sought to decrease the hazard of loss of this kind by limiting the size of the pipe in some cases to as small as four inches, and some of these are now merely following an old custom established many years ago before the science of fire protection was well developed. In order to obtain a general view of the prevailing water works practice, the Inspection Department in the latter part of 1922 made inquiries of the water departments serving our members as to the size of connections, charges for fire service, use of meters, etc. This inquiry was sent to 259 cities and towns in 19 States and is sumarized as follows:

This question relating to the size of connections was answered by 239, of which 181, or 76 per cent were municipally owned, and 58, or 24 per cent, were privately owned water works.

Of the 239 who replied to this question:

	Municipal	*Private*
9 made definite restrictions to 4-inch size	6	3
99 allowed connections up to 6 inches	76	23
54 allowed connections up to 8 inches	39	15
10 allowed connections up to 10 inches	8	2
6 allowed connections up to 12 inches	4	2
32 made no restrictions		
13 allow connections from 50 to 100 per cent of capacity of main.		

Those not included in the above list make indefinite replies, indicating a general policy of treating each question as a special case.

This survey of general practice and the lack of unfavorable experiences in the use of the larger connections where properly controlled indicates a very general recognition of the value of private fire protection system and the need of giving them an adequate supply of water. In looking over the reports of committees of water works on this subject, there does not appear to have been much progress made in fixing a standard of practice and this is not surprising as this is in many cases a complicated engineering problem. The fundamental point, of course, is to bring about the use of water in the way that will most surely extinguish the fire, prevent the destruction of property and the possible spread of conflagration extent with great community loss.

A 50 per cent limit such as was suggested in the report of the American Water Works Association of 1919 would not always accomplish this, for if there were no limit to the number of connections within a given distance along the main, it would still be possible to have an aggregate capacity of connections many times the capacity of the pipe, and if a number of such connections were used to feed into a single fire system of considerable size as in some large factories, the multiplicity of connections would result in more delay in shutting off than if fewer and larger connections were used. In some cases this limit would not safeguard the general water system as expected and in others it would restrict the flow unnecessarily with no benefit to the system as a whole, possibly serious detriment to the particular property needing the protection.

For example, if the main is very long so the friction loss is large and the amount of water it can discharge at good pressure is comparatively small, short connections based on the 50 per cent limit might still be able to carry into the fire system even more water than the main could supply. On the other hand, if the main were short, the friction loss negligible and the pressure low, the 50 per cent limit would result in holding back a very considerable flow otherwise available for the sprinkler system. Such a limit would have to be used with great discretion. For best results, general reliance must apparently still be on proper means of control and a good system of handling such a means of control in an emergency. Thus far it has been found extremely difficult, if not impossible, to find anything which will replace satisfactorily intelligent human control.

Mr. J. G. Valentino: Down our way we have considerable trouble because everybody and his brother uses the fire hydrant. If some of the other superintendents will tell me of some way to eliminate that, I will appreciate it.

Mr. Sterosky (Port Huron, Mich.): The way we try to eliminate it is to purchase a valve and place it on the fire nozzle of the hydrant and then turn the hydrant on and leave it on. That does not wear out the valve seat and they draw the water and use this valve for filling their tanks. That is not very practical because there can be only one valve on a hydrant and if a fire broke out you would have to put two streams of hose on the hydrant.

Mr. J. M. Diven: What I am trying to bring out, but not with very much prospect of success, is to have a connection or flush hydrant to be shut off in the winter, tapped on the hydrant branch giving about a two inch tap on a six inch hydrant branch and a two inch wash pave, you might call it, and restrict them to a two inch hose for filling their tanks. They would have a hose that they could not hook on a hydrant; if you let the flusher have a hose that he could connect to a hydrant he would go to the hydrant because it was easiest, but one means I believe of bringing this about is by publicity in your own city and by influencing public sentiment, telling them the dangers of hydrants being out of order and the possible bad fire losses from this. It is not only street flushers, etc., but contractors and everybody else, sewerage flushers, etc. If you can only get the people in your town to understand the danger that they are running by allowing the use of hydrants and the hydrants being out of order, get them to understand that the water department cannot be responsible for the condition of the hydrant when it is wanted for fire, if other people are allowed to use it, and finally bringing about a restriction that nobody, but the water department or fire department men should have access to the hydrant if you can only educate the people to that, that is the only way you can succeed.

PROTECTION OF FIRE HYDRANTS

Mr. J. E. Gibson: I have recently heard of one solution for this trouble that I think is very plausible and I would like to try it out. The solution is to locate fire hydrants about 100 feet back from the corner so that the fellow in turning the corner if he wants to, may run upon the sidewalk; and by the time he reaches the hydrant he has had time to sober up and get back into the street. Our fire chief does not approve of this method and prefers the hydrant near the corner so that he can, as he says, cover a larger territory from each hydrant.

Mr. W. H. Buck: If you want to get them out of the road of the reckless driver, you will have to put them back in the field. I had an experience about a month ago on the State Highway between Trenton and Camden; about 5:30 in the afternoon the telephone rang and my men had all left, and it was raining and there had been an accident out on the State Highway which used to be the Burlington Pike about four miles from the office. I jumped in the car and went out there and I saw a big Cadillac sedan standing there. The driver came along, the fire hydrant was there, there was no crossroad anywhere near, the fire hydrant was down about 25 feet from the center of the road, but when I got there there was just a spurt of water coming up, there was a telegraph pole within six inches of this fire hydrant and both the hydrant and pole were gone and the transformer had come down and it just took part of the running board on the other side of the machine away. The driver backed out and went away under his own power down the road, so I thought that that beat a Ford car to a standstill.

DRY WEATHER CONDITIONS CAUSING SHORTAGE OF WATER; EMERGENCY MEASURES USED TO MEET SUCH CONDITIONS

Mr. E. L. Filby: I can give you the experience of Newberry, S. C., if you desire it. Newberry is a small city deriving its water supply from driven wells located at various points in the city. The superintendent noticed that the stand pipe gradually dropped. There was no well he could put down in time and he had a small stream that went right past his plant. He decided in the emergency to pond the stream, put on a chlorinator, heavily overdose the water, discharge into a small clear well and then pump to the stand pipe. That looked nice on paper and we went over the stream, located all sources of pollution we could and proceeded to remove them. We found one abbatoir discharging its wastes into the stream, several privies on or near the stream and one septic tank discharging into the stream. We cleaned up the water shed, ponded the stream, put on the chlorinator and told the people what we were going to do. They said they knew more about the stream than we did—and raised quite a howl about it—refusing to drink the water, etc. and they actually cut down their consumption of water enough to allow the immediate shortage to be relieved. We had a supply ready for them—a supply that was bad looking, but probably not dangerous. We are still holding this threat over them but working fast to get a filter plant installed on another creek.

Mr. J. M. Diven: Mr. D. W. French, if he is here, ought to be able to give us some information on this. He has several cities supplied with the Hackensack Water Company's water and they had to shut down on the water supply for all factories, reserving the water supply for domestic use and fire protection, and something over 30,000 men were thrown out of employment by that. I have understood that the citizens gave the water company splendid co-operation at this time.

Mr. H. M. Freeburn: It might be interesting to know of a water shortage caused by too much rain. In a town of 15,000,

they have a water supply taken from a surface stream on which there is a hundred million gallon impounding reservoir. From the reservoir the water is normally delivered by gravity to two mechanical pressure filters and three slow sand filter units.

After a very heavy rainfall on the upper portion of the catchment area a considerable quantity of disintegrated material, almost like talcum powder, was washed into the impounding reservoir. The turbidity caused by the entrance of this deposit in the water was not materially reduced by settling in the impounding reservoir due to its colloidal nature, and heavy wind causing strong wave action, combined with the spring turnover.

This water clogged the slow sand filters and at the same time it was found that the pressure filters were not capable of delivering water at their rated capacity because the concrete, which had been placed along the sides and ends of the units to eliminate the curve surfaces, had fallen over on the filter bottoms.

The pressure filters were overhauled, the slow sand filters were cleaned as frequently as possible and wide newspaper publicity was given to the absolute necessity for the conservation of water. Conferences were held with the officials representing the largest consumers with the request to reduce the consumption of water in their establishments to a minimum.

Along with information setting forth the daily developments in the water situation, the following article in heavy type appeared daily on the front page of the city newspapers:

RULES AND REGULATIONS FOR USE OF PUBLIC WATER

The following rules and regulations are promulgated in order to conserve the water supply for the city during the present water shortage and to forestall, if possible, the necessity of only continuing service during a portion of the day or turning raw water into the distribution system. These regulations will be strictly enforced during the present emergency.

1. No public water shall be used except when absolutely necessary.
2. Automobiles, wagons, etc. must not be washed.
3. Windows, porches, pavements, cellar cement floors, etc. must not be washed.
4. Water must not be allowed to run continuously in water closets, urinals, etc.
5. Restaurants and hotels must use only enough water to prepare food and wash essential dishes.
6. Water used in building construction must be reduced to a minimum.
7. All leaks in plumbing fixtures and piping should be repaired at once.

8. All water spigots must be kept closed except when drawing water for immediate and necessary use, after which time they must be closed.

9. Drinking fountains must not be allowed to run continuously.

10. All industries should make an immediate survey of all water piping on the establishment and take prompt action to reduce the use of water to a minimum and prevent waste.

11. Any individual, company or corporation violating any of the above rules will have the water supply cut off immediately.

Approved April 18, 1923.

H. M. Freeburn, (Signed) Mayor
District Engineer,
Penn. Dept. Health. (Signed) Supt. Water Dept.

Mr. Diven: Did they do it?

Mr. H. M. Freeburn: Yes, every one coöperated splendidly, as the city in the past had had several severe typhoid fever epidemics and the people knew the danger of introducing unfiltered water into the distribution system. The city police made inspections, and some of the citizens who did not comply with the rules and regulations were notified to stop certain water waste. This water shortage was instrumental in having the city officials secure the services of a consulting engineer to prepare plans for additional filter capacity and at the present time the city is constructing open gravity rapid sand filter units in one of the existing slow sand filters.

Mr. O. E. Bulkeley: Those were fine as emergency measures, but when such shortages occur they should be regarded as distress signals. In the water works business, we are too prone to look upon these shortages as something extraordinary and do not feel keenly enough the obligation to meet them. The customer pays for water and likes plenty of it. During the summer season a large amount of water is required for sprinkling of lawns and when we find it difficult to meet the demand at that time of the year, we should lose no time in taking steps to increase the supply.

In Lansing, Michigan, we have faced the same situation, but are thankful that our supply has now been increased so that we can easily meet the heaviest demand. The large public utilities supplying light and power are able to supply the demands at all times during peak loads and are constantly adding to their capacity, so that they will have reserve, but many of the water utility companies and municipalities are not sufficiently alert in providing capacity for future needs.

Mr. J. E. Gibson: It is a question of educating the public. I am quite sure that all of us realize where we are and where the shoe is pinching us, but the difficulty is to get the laymen, the public and our commissions to look farther ahead in the future. As an illustration; we had two pumping engines that had been running about 20 years, giving excellent service. We had a third engine of half the capacity of each of the main engines. Our consumption had grown gradually until it was necessary to run both of the large engines to meet the peak load. I was anxious to put in a third engine of the same capacity as the two larger so that I could shut down and make repairs as desired. One of our commissioners said, "Gibson, how long have these engines been running," and upon my reply that they had been installed in 1902 he said "they have run about twenty years and it looks to me like they are good for twenty more." Fortunately for us, I was permitted to install a third engine and have since overhauled the two old engines, and I fully believe that they are good for another 20 years.

INDEXING AND CLIPPING ARTICLES

Mr. E. E. Bankson: If the members have noticed the work of the Abstracts Committee that you get in the back of the Journal, it is all along the line of this question, and then once a year an index comes out of those abstracts. It surely would offer you a very good key in answer to this question, that is a certain angle of it. The abstractors are doing a very important work in this direction; they are doing it for the Association; the chief abstractor is giving an awful lot of his time finally in preparing the index of abstracts, and it would be a pity if everybody does not take advantage of this extensive work that is being done.

Mr. J. E. Gibson: I want to say in this connection that the joke is on me. In looking over the author's index I was surprised to see my name and could not recall having said anything that was really worth abstracting; and before I could convince myself I had to look up the article that had been abstracted to make sure that no mistake had been made.

Mr. J. M. Diven: The trouble with the Indexing and Abstracting Committee is that as years go by we want to find some particular subject and we have got to dig back eight or ten years before. What you ask the Abstract Committee to do has been very little expense, I think, but the matter was sent out to have proof sheets printed on one side of all the abstracts sent to the members, so they could then pick out the particular items they wanted. I went through that very carefully for several numbers and found on average there was about one out of six articles that personally interested me. The idea was that these clips could be suspended on cards and indexed and in the future they would be much easier to refer to. Some of us who are interested perhaps in pumping, etc., are not at all interested in filtration, and we would only put in the index articles we were interested in. My own practice for a great many years has been to use a five by eight card and make my own abstracts of the article, sometimes indexing it and cross indexing it and referring

to the article itself; but usually on a five by eight card one can write the gist of the article, enough to give them the information they want. It seems to me something very much more convenient to refer to than going back to that index.

SEGREGATION OF WATER RATES

Mr. J. E. Gibson: What progress have you made in dividing rates into their various uses, such as fire protection, manufacturing, commercial, domestic? Such segregation is desirable and the progress that has been made will be interesting.

Mr. Bankson and I had the pleasure of discussing a report of useful data to be filled in by the waterworks plants, privately and municipally owned. The idea was that these would be sent out to the superintendents of our Association and be filled in and returned by them to the Secretary, whereupon he would compile and print in the proceedings annually the essential information thereby obtained for the general information of the Association. One of the items in these proposed useful data is the *Segregation of Commercial and Domestic Water*. If our departments are not now doing this it would be well for each superintendent to consider the matter during the coming year because sooner or later you will get a copy of this proposed report with the idea of criticising it. I hope we will criticize it in the spirit of constructiveness, as we want to get the essential information without making it burdensome to all.

Mr. J. M. Diven: It is almost impossible to get these data except in a largely metered community, but we pick up reports, and the consumption of cities is in some cases 80 or 90 gallons per capita; that is probably a residential district. In another city where it is thoroughly metered they may be using double that amount of water and the larger amount of it for mechanical or commercial purposes, and any comparison of one place with another without that knowledge is very misleading and it is something we all ought to work to. We ought to get information as to how much water is used for domestic use, how much for manufacturing use; those are the three classes Mr. Cole's report took up, and also how much is unaccounted for, possible used for fire extinguishing, street sprinkling, etc. I think we ought to work to that end and get at it as rapidly as we can, even if we cannot get that knowledge complete, let us make a start, let every one of us make as careful an analysis as we can of

the water consumption. I live in a city where the water consumption is very high; we are only using 324 gallons per capita; that includes everything. Unfortunately we are not largely metered, but I am trying to get some idea of the use of water for various purposes. The water is neither pumped nor filtered.

FORESTATION OF WATERSHEDS

Mr. J. M. Diven: In the State of New York they started in some years ago supplying us the seedlings at almost a nominal price, at cost. They are now supplying them without any charge whatever. The city of Troy placed the first year 240,000 trees. They have continued planting until the number is about 500,000 now, and my application is in for 1,000,000 trees, which will take care of all of the watershed. Some of this land has been rented for farming purposes, but is not much used any more, for it has been run out, and, luckily, the more the land is run out the better the trees do, for some reason. In time there will be a valuable forest there; trees set out ten years ago are now 15 or 20 feet high, pines almost entirely.

Mr. J. E. Gibson: We do not have to do much reforesting in our climate as the trees will reproduce very rapidly. Our trouble is from forest fires. The long leaf yellow pine is rather rugged and will resist a pretty good fire, but the short leaf yellow pine is killed readily. Short leaf yellow pine, even 20 feet high, will be killed from an ordinary fire whereas the long leaf pine 20 feet high will stand a pretty severe forest fire and still survive. Hunters, hunting jack-rabbits or quail, that have been hunting for years over land seem to feel that they have obtained certain rights and will not respect trespass notices unless you haul them into court. This usually results in bad feeling and, in many cases, they will appeal to jury trials and the jury, being in sympathy, will refuse to convict and the worst penalty, in many cases, is advice from the judge to cease trespassing. Nevertheless, most of our forest fires are caused from this class of hunters who are either careless or indifferent to your rights.

A government expert recently stated to me that, unless we took better care of our growing timber and stopped forest fires, it would be only a question of a few years before we would be devoid of any kind of building timber in the South Atlantic states.

Mr. J. M. Diven: Our State Conservation Commission is looking at that very carefully, erecting signal towers through the district that is being reforested or where the old forests exist.

Mr. Meyer (Glens Falls, N. Y.): I would like to ask Mr. Diven how many trees were set out?

Mr. Diven: We set them out 6 feet each way; that means about 1200 trees to the acre.

Mr. Meyer: We have had quite a lot of experience in Glens Falls. Since 1910 we have reforested about 1000 acres by planting about 1,200,000 trees. Those first set out, which were seedlings, have attained a height of from 12 to 15 feet, with butt measurement of from 3 to 6 inches in diameter. In our recent plantations, through and by which public highways run, we plow a dead furrow about a rod wide every two or three hundred feet in each direction to enable us to control and combat more easily forest fires in the event of their getting into the plantations. We believe such a gridironing with fire lanes to be essential to the protection and preservation of these growing forests.

Mr. Diven: You have a fire signal station established by the Conservation Commission, have you not?

Mr. Meyer: We have one at Prospect Mountain, about 5 miles distant from our plantations. Have you any data, Mr. Diven, as to the cost of planting?

Mr. Diven: I understand that some gun clubs, Boy Scouts and others are offering to do the work, but the work of the Boy Scouts, as I have seen it, is very unsatisfactory. My recollection is that 240,000 trees were set out at a cost of a little under $2000. Then we had to pay something for the trees. I should say about half of that cost was for planting and the balance was for the trees themselves. Now the trees are furnished without cost.

Mr. Meyer: The cost at Glens Falls varies from about $2.50 to about $8.00 per thousand, depending on how flat, rolling or rough, and accessible to team or motor transportation the lands may be.

Mr. Diven: It is money well spent.

Mr. Meyer: Very. We estimate that, beginning with the end of the next 25 years, our city will derive an income of approximately $1200 per acre from the acreage planted 40 years prior. And our plantings have been so planned that when cutting once begins it will be possible to cut from 20 to 25 acres each year and immediately to replant, so obtaining what really might be termed a perpetual annual income. These estimates are based on a loss of from 40 to 50 per cent of the original number of trees planted, which would seem conservative, and on the theory that at the end of 25 years a market of pine would have a value of $2.00 on the stump, and that each matured tree would contain approximately a market log. Aside from this investment value to the city, we are obtaining a wonderful cover on our water shed lands which prevents the rapid melting of the snows in the spring and so automatically controls the runoff which finds its way into the ground instead of over the ground and will in time have a very direct bearing on the uniformity of flow of the streams and springs supplying our storage and intake reservoirs.

ADVANCE PLACEMENT OF SERVICES

Mr. J. G. Valentino: Where it is undeveloped territory, we use pushers. When they pave a street, we require a service line to be run in ever 60 feet.

Mr. J. E. Gibson: Who pays for it?

Mr. Valentino: The property owner pays for it, because we will not allow him to break that pavement again for five years.

Mr. Sterosky: In Port Huron, where the street is paved we lay our service to the curb and it stays there until the property owner builds. When he requires the water he goes to the office and pays a flat rate of $25.00 and that pays for laying the pipe from the main to the curb.

Mr. Diven: And if he never builds, the service is a loss to you.

Mr. Sterosky: Well, we expect that some day he will build where there is a paved road, and as a rule he does.

Mr. Valentino: I would like to ask Mr. Chester why he advises not to do it.

Mr. J. N. Chester: What per cent of the services put in are subsequently utilized before they rot or rust out?

Mr. Valentino: In our territory, when they pave a street inside of four or five years it is practically built up. Building will follow a paved street in our territory and if you do not do it, you will get your paving broken up continuously. Whenever you break a pavement, especially where it is sandy, it takes some time for that sand to settle. In fact we have to go along where they break concrete or this asphalt pavement and put in bricks temporarily for about a year, and then come along and repave it. If you do not do that, you will have a sink in your boulevard.

Mr. Diven: One objection to those forced laterals is that the sewer lateral is usually put in at the same time and a leak in that service run away into the sewer and waste an immense amount of water without ever showing on the surface or anyone ever knowing of it. We put them in in Troy five feet deep, and that is, as far as we knew, the lowest frost limit. Five or six years ago we had a severe winter and 55 of those services that had not connected up were frozen and we had to dig the street up anyhow.

Mr. Valentino: Sixteen inches is all we require.

Mr. Gibson: We put some services in in advance of paving during the war period. We have probably since connected up 30 per cent of these. This particular subdivision was laid off in 25 and 30 foot lots and we put a service to each lot. A purchaser usually purchases two lots and when it comes time to sign up for water either of two things happens. Our clerk, in making contract loses sight of the fact that there are two services in this property and fails to make proper charge for taps, or the consumer raises a strenuous kick that he does not need two services and does not see why we should charge him for more than one. I am very much against the putting in of services until someone is ready to take water.

Mr. Diven: You have not only got a service you do not get paid for, but one that will be a nuisance, and some man will want to build on another part of that lot.

Mr. Chester: I am reminded of that Western boom town that paved miles of streets and nobody built on them; but that is what our Southern friends do not think of.

WATER, SEWER AND GAS PIPE IN SAME TRENCH

Mr. D. H. Heffernan: There seems to be an increasing tendency in New England to install all house supplies, water, gas and sewer in one trench, the purposes being twofold, economy of installation and preservation of roadways. Broadly speaking I do not favor the plan and would like to know what experience, if any, some of the communities here represented have had along this line.

A Member: Tidewater, Va. has a different soil from the soil you have in New England, and putting the sewer line and water in the same ditch, you run the risk of a leak that will not show; Our company will not allow a service to go in the same ditch with the sewer. If soil conditions were the same, from your experience I would not recommend that proposition, at least as to the sewer. As to the gas, I think it would be all right.

Mr. Diven: The gas main is usually more shallow in the northern climate than the water pipe, but the sewer pipes as a rule are very much deeper than our water pipes, so that the water pipe is laid in the fresh filled soil, which is certainly not a good practice. It is the practice in New York City in rock and is probably all right in that case, they dig a little bench for water service, but it seems to me a great mistake to put a water service over a sewer in a sewer trench which is probably twelve or fifteen feet deep, as is often the case. Sewers are usually deep enough to drain the sub-cellar, which is considerably lower than we are in the habit of laying the water services. Another thing, the joints in the sewers are not always as tight as they might be, as they are supposed to be, but they are put in by contractors instead of water works men, so they are not as good as they might be. Very often, if for any cause there is a leak in the water service, the water finds its way into the sewer and does not show on the surface and we have a considerable loss of water in that way.

CARE OF HYDRANT DRIPS IN WET SOIL WHERE SEWERS ARE NOT AVAILABLE

Mr. Sterosky (Port Huron, Mich.): We pull the hydrant up and plug the waste and pump the hydrant out.

Mr. Diven: Then keep it pumped out.

Mr. Sterosky: We have an inspector going around, sometimes several, and they carry a pump with them and test out the hydrant, where they find water in it they pump it out; if the water fills in the next day, we jerk the hydrant up and pump the waste.

Mr. Heffernan: The type of hydrant we use may be plugged by the use of special sleeve, without more work than removing the dome and a top pressure plate, although I frankly admit I am not strongly in favor of the method. My plan is to make several inspections at the opening of the winter to determine which hydrants hold surface water. These are treated with denatured alcohol in proper proportions, depending on the height of the water in the barrel. With hydrants so treated we have never been troubled even in extremely cold weather.

Mr. Diven: Someone talking about thawing a hydrant, spoke about putting a small piece of calcium carbide in it, and when it struck the moisture it produced gas and heat. I was a little in doubt as to whether that would not destroy the hydrant valve, which is made of rubber. Have you tried it?

Mr. Heffernan: No. I have not had experience with calcium carbide.

CROSS CONNECTIONS

Mr. H. A. Burnham: There have been no troubles that we have heard of from any of these connections during the past year, and we have about a thousand of them in use on fire services only. There are doubtless many others not under our jurisdiction.

Mr. J. N. Chester: Is that due to the fact that the factory that uses those cross connections has an unpolluted source?

Mr. Burnham: No, the record is probably due to the fact of the improved construction and the frequent inspections and also the frequent examinations; in other words, excellent maintenance.

Mr. Diven: What kind of check valves?

Mr. Burnham: The double check valves known as the "Special Type F. M." check.

Mr. Chester: Constantly open to the atmosphere?

Mr. Burnham: No, these are placed between two gates and the whole set of valves is in an accessible pit. Under ordinary conditions the city water pressure is on and the main gates are open.

Mr. J. N. Chester: But in your two check valves, do you not make a tap in the bottom?

Mr. Burnham: They are provided with the usual drain or test connections for making the quarterly tests for tightness.

Mr. Chester: But those connections are closed.

Mr. Burnham: Certainly, if not the water would escape into the pit because the main gates are always open.

Mr. Chester: But you have got a double check; you expect the first to hold and the second not; if you leave it open and have got a leak up there, you have got a warning.

Mr. Burnham: That is the purpose of the two checks. The drain can be left open only when conditions are such that the first main gate can be normally closed. That is not a condition commonly found.

Mr. Diven: How often is the test made?

Mr. Burnham: We expect to test them at every visit, and with our companies the visit is every three months. In many places the checks are opened every year, the clappers are swung up out of the body and cleaned off and the interior of the valve wiped clean, the rubber facing is examined and, if it requires renewal, it is renewed. That is the character of the inspection.

Mr. Diven: Are not some of them in pits that are inaccessable during the winter?

Mr. Burnham: Some of the earlier ones were not very favorably placed and it is difficult to get at those.

Mr. Diven: I have had to place one in the street.

Mr. Burnham: It is possible to make the pit as watertight as a cellar and it should be done for that kind of connection.

Mr. Diven: You mean an entrance to the pit from the cellar?

Mr. Burnham: Not necessarily. The entrance is through a man hole, if in the street.

Mr. Diven: But suppose your street is covered with a foot or two of snow and a little ice?

Mr. Burnham: Usually where it is outside of the property line, they are in the sidewalk.

Mr. Diven: In that case there was a pipe along the curb line which branches into the various parts of the factory and there was absolutely no place for the check valve except in the street.

Mr. Burnham: In an extreme case there would be no objection to putting it in the basement of the building, that would be preferable to the street. If you put it where you cannot examine it, it will cause trouble later.

DISCUSSION

BACTERIOLOGICAL STANDARDS

From table 1 it may be seen that 50 per cent of the 18 water supplies in Illinois, for which we have a record, would pass the new bac-

TABLE 1

City	Number samples tested	Number of portions	Number samples showing positive tests in						10 per cent all tubes may show gas		5 per cent all samples more than 3/5	Conforming to standard	City supplies conforming to proposed standard	Per cent samples not passing present standard
			0/5	1/5	2/5	3/4	4/5	5/5	Per cent positive tubes	Conforming to standard	Per cent sample with 3 or more positive out of five 10 cc.			
1	145	725	119	17	5	1	1	2	6.0	Yes	2.7	Yes	Yes	5.5
2	8	40	8						0.0	Yes	0.0	Yes	Yes	0.0
3	69	345	55	6	3	3		2	8.9	Yes	7.1	No	No	11.5
4	58	294	17	15	11	5	5	5	32.9	No	25.9	No	No	44.8
5	44	220	38	4	1			1	5.0	Yes	2.2	Yes	Yes	4.5
6	66	330	47	7	2	5		5	15.4	No	15.1	No	No	18.1
7	56	280	27	5	8	6	2	8	31.0	No	28.5	No	No	42.8
8	66	330	43	6	4	1	7	5	21.2	No	19.7	No	No	25.7
9	71	355	49	7	3	1	5	6	18.5	No	16.9	No	No	21.1
10	63	315	39	15	1	5	3		13.9	No	12.7	No	No	14.2
11	69	345	64	2		1	1	1	4.0	Yes	4.3	Yes	Yes	4.3
12	88	440	80	4	1	1		2	4.3	Yes	3.4	Yes	Yes	4.5
13	68	340	19	12	0	8	7	12	42.3	No	39.7	No	No	54.4
14	70	350	66	2	2				1.7	Yes	0.0	Yes	Yes	2.9
15	59	295	55	1	2		1		3.0	Yes	1.6	Yes	Yes	5.0
16	67	335	59	5	2	1			3.9	Yes	1.4	Yes	Yes	4.4
17	71	355	46	16	6	2	1		10.7	No	4.2	Yes	No	12.6
18	74	370	56	9	3	1	2	3	11.0	No	8.1	No	No	12.1

Samples tested between January 1, 1918, and February 26, 1924.

terial standards proposed by the committee of the United States Treasury Department, (includes No. 17 which is on the border of the A clause), and that only 1 out of 18 or 5.5 per cent conform to the present standard all the time, 65 per cent fall short 5 per cent of

the time and 50 per cent fall below the present standard 12 to 15 per cent of the time and 36 per cent fall below 20 to 50 per cent of the time. The proposed standard would therefore appear less drastic and more practicable than the present one.

A. M. BUSWELL[1] AND R. A. SHIVE.[1]

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ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Figuring Centrifugal Pump Characteristics from Those at Known Speed. F. C. EVANS. Power, 59: 13, 487, March 25, 1924. Pump characteristics at a known speed are assumed and calculations made to determine characteristics at a lower speed. Calculated and actual characteristics were found to agree within reasonable limits.—*Aug. G. Nolte.*

Operating Instructions for Large Turbines. Power, 59: 13, 490, March 25, 1924.—*Aug. G. Nolte.*

Operation of Static Transformers. B. A. BRIGGS. Power, 58: 15, 570, October 9, 1923. Author explains how voltage transformation takes place; relation between primary and secondary currents; rating of transformers; and methods of connecting the windings for different voltages.—*Aug. G. Nolte.*

Steam Trap Installation and Operation. R. N. ROBERTSON. Power, 58: 15, 573, October 9, 1923. Brief analysis of trap installation and operating conditions.—*Aug. G. Nolte.*

Factors That Affect the Life of Iron Stacks. P. R. DUFFEY. Power, 58: 15, 582, October 9, 1923. Author's experience teaches that failure of stack where steel guy bands are placed is due to local rusting action. To overcome this it is recommended instead of having band come in direct contact with stack that it be held away at least $\frac{3}{8}$ in. by spacers the width of band and 3 in. long, welded to band. Other factors affecting life of stacks are given. —*Aug. G. Nolte.*

Correcting Vibration in Reaction Type Turbines. L. LONG. Power, 58: 16, 609, October 16, 1923. Principal causes of vibration in small or medium-sized reaction turbines are given. Methods of detecting cause, and elimination thereof, are discussed.—*Aug. G. Nolte.*

Operating Hydro-Electric Plants To Obtain Most Economical Output. RALPH BROWN. Power, 58: 16, 614, October 16, 1923.—*Aug. G. Nolte.*

The Selection and Care of Pyrometers. J. W. CONZELMAN. Power, 58: 17, 644, October 23, 1923. The fundamental principles underlying operation

of electrical pyrometers are explained: many practical pointers on selection and care of thermocouple instruments are given, including detailed instructions for making, calibrating, and installing.—*Aug. G. Nolte.*

Grinding Commutators With Artificial Commutator Stones. E. H. Martindale. Power, 58: 17, 647, October 23, 1923. Briefly describes process of manufacture, shows proper method of using commutator stones; precautions necessary; and treats briefly the machine troubles which make frequent grinding necessary.—*Aug. G. Nolte.*

Characteristic Curves of Centrifugal Pumps. R. K. Annis. Power, 58: 17, 653, October 23, 1923. Characteristic curves of pumps for various services are illustrated and discussed with view to selecting most efficient type for the service.—*Aug. G. Nolte.*

Diesel Engines Reduce Operating Costs. Power, 58: 18, 689, October 30, 1923. Operation of the two 550-hp. Nordberg two-cycle verticle Diesels, purchased by Municipal Light and Water Plant of Neodesha, Kansas, is described.—*Aug. G. Nolte.*

Boiler-Feed-Water Circuits in Power Stations. Power, 58: 18, 705, October 30, 1923. Abstract of paper presented by James G. Weir of Glasgow, Scotland, before Koninklijke Institute Van Ingenieure (Holland). Methods of operation of open and closed feed-water-circuits are described and discussed very extensively.—*Aug. G. Nolte.*

Deterioration of Turbine Oils in Use. A. Duckham and S. E. Bowrey. Power, 58: 18, 707, October 30, 1923. Principal source of trouble lies in tendency for condensed steam from glands, or water from cooling system, to find its way into oil in quantities large enough to hinder proper functioning. Suitable oil should separate readily from water and retain this property during long periods of use. Water may then be drawn off at intervals. Oil oxidizes at normal temperatures, and the oxidation products prevent ready separation of the water. Light oils show relatively less deterioration due to oxidation. Other causes of deterioration are entrance of impure water and dust.—*Aug. G. Nolte.*

Notes on Pressure Regulators. C. C. Brown. Power, 58: 19, 732, November 6, 1923. Installing, adjusting, operating, and overhauling of steam pressure regulators are discussed.—*Aug. G. Nolte.*

Steam vs. Electric or Gasoline Drive for Centrifugal Pumps. Power, 58: 19, 735, November 6, 1923. Data submitted by the Hill Pump and Turbine Works of the Midwest Engine Corporation, Anderson, Ind., show that fuel cost for steam turbine is much lower than equivalent cost for electric motor or gasoline engine. Fixed charges, labor and depreciation are greater for steam. Readiness to serve, standby cost, and the ever-increasing developments in

hydro-electric and superpower station fields are causing the electric-driven centrifugal pump with gasoline-driven standby unit to become popular.—*Aug. G. Nolte.*

Determining the Economical Interval Between Cleanings of Condenser Tubes. C. E. Colborn. Power, 58: 21, 803, November 20, 1923.—*Aug. G. Nolte.*

The Meaning of Atmospheric Pressure. T. M. Gunn. Power, 58: 21, 811, November 20, 1923. The principle of the mercurial, barometer is illustrated, and method of reading it, described.—*Aug. G. Nolte.*

Improvised Automatic Time Signal. H. Hughes. Power, 58: 21, 818, November 20, 1923. An alarm, or signal, for various services around a plant is illustrated and described.—*Aug. G. Nolte.*

Periodic Examinations of Steam Turbines. Power, 59: 15, 563, April 8, 1924. Instructions of Westinghouse Electric and Manufacturing Co. on periodic examinations of steam Turbines.—*Aug. G. Nolte.*

Measuring the Feed Water in a Boiler Test. J. W. Gavett, Jr. Power, 59: 15, 567, April 8, 1924. Several methods illustrated and described.—*Aug. G. Nolte.*

Keeping Solid Impurities Out of the Air-Compressor Intake. W. V. Fitz-gerald. Power, 59: 16, 599, April 15, 1924. Harmful effects of impurities in intake air discussed. Device is illustrated and described, to remove solids and gritty substances from the air.—*Aug. G. Nolte.*

Checking Field-Coil Connections on Direct-Current Machines. A. C. Roe. Power. 59: 16, 601, April 15, 1924.—*Aug. G. Nolte.*

The High-Power Diesel Engine of Nürnberg. W. Laudahn. Power, 59: 16, 603, April 15, 1924. Zeitschrift des Vereins Deutscher Ingenieure, Dec. 8, 1923. Difficulties met with in designing 12000-hp. Diesel Engine; account of the explosion that wrecked the engine.—*Aug. G. Nolte.*

Action of Caustic Soda on Boiler Steel: A Preliminary Report of M. I. T. Experiments. R. S. Williams. and V. O. Homerberg. Power, 59: 16, 609, April 15, 1924. Paper presented before Boston Chapter of American Society of Steel Treaters. Electrolytic hydrogen and caustic soda are indicated as factors in failure of boiler metal under stress. Action is mainly on the inter-crystalline impurities. Hydrogen acts chiefly upon oxides, while hot caustic soda solutions dissolve out sulfides.—*Aug. G. Nolte.*

Epidemic of Typhoid Fever and other Intestinal Diseases in Everett, Wash., July, 1923. C. E. Dorisy. Public Health Reports, 39: 13, 605, March 28, 1924. It was discovered that the drinking water was being polluted by river water which gained access to mains through a faulty cross-connection in a dual

fire protection system, which was immediately ordered shut off and sealed. Seventy-seven cases of typhoid fever and at least 2000 cases of diarrhea and dysentery ensued among the population of about 30,000. There were 9 deaths from typhoid and 2 from dysentery. In January, 1924, Washington State Board of Health passed regulations prohibiting use of cross-connections for any purpose, unless both water supplies were of safe sanitary quality and connection has received approval of State Board of Health, and prescribed several methods whereby public water supplies might be made available for fire protection.—*Aug. G. Nolte.*

Turbine Specifications and Bids for Detroit Municipal Plant. Prepared by Smith, Hinchman and Grylls of Detroit. Power, **58:** 22, 845, November 27, 1923.—*Aug. G. Nolte.*

Fedce Protectometer Systems for Stored Coal. Power, **58:** 22, 850, November 27, 1923. The Protectometer Company of Jersey City, N. J. have developed a system whereby any case of heat development may be detected in sufficient time to permit removal of hot coal before serious loss of heat value incurred. Instruments comprising this system are illustrated and described. —*Aug. G. Nolte.*

Fitting the Electric Motor to the Pump. R. H. Rogers. Power, **58:** 25, 976, December 18, 1923. Effects of pipe sizes on cost of pumping; effect of methods of controlling pump output on power consumption; pump characteristics, and choice of motor and control equipment.—*Aug. G. Nolte.*

Diesel Engines for Water-Pumping Plants. A. R. McMullin. Power, **58:** 25, 984, December 18, 1923. Illustrations of Diesel Engine installations for Water-Pumping Plants. Comparative operating costs of various types of Water-Pumping Plants are tabulated, from which the oil engine appears equal, if not superior, to any other form of power producer, while its life is such that depreciation is a minor element in total operating charges. Suitability of Diesel Engines for water works service is indicated.—*Aug. G. Nolte.*

The Value of Instruments for High-Grade Boiler-Room Operation. H. H. Bates. Power, **58:** 25, 988, December 18, 1923. The use of various instruments is discussed. Table of boiler conditions detectable by means of instrument readings is appended.—*Aug. G. Nolte.*

Babbitt Metals and How to Babbitt Bearings. E. Andrews. Power, **59:** 2, 57, January 8, 1924.—*Aug. G. Nolte.*

Is Coal Storage Worth While? Power, **59:** 2, 42, January 8, 1924. Problem is briefly discussed from the viewpoints of the mine operator, and of the consumer.—*Aug. G. Nolte.*

Corrosion-Resisting Alloys and the Mechanism of Corrosion. Chem. & Met. Eng., **30:** 17, 671–73, April 28, 1924. Contributions presented at the

New York joint meeting of 4 technical societies. **Fundamental Factors of Corrosion.** W. G. Whitman and R. P. Russell. Experimental evidence strongly indicates that corrosion is electrochemical, and operates through a corrosion cell. The metal sends ferrous ions into solution at the anodic electrode according to the reaction $Fe + 2(^+) = Fe\ (^{++})$. A corresponding reduction occurs at the cathode area, usually the deposition of hydrogen ions as atomic hydrogen or the ionization of dissolved oxygen to hydroxyl ions. The cathode reaction for hydrogen deposition may be expressed as: $2H^+ = 2H + 2(^+)$: that for oxygen ionization as: $\frac{1}{2}O_2 + H_2O = 2OH^- + 2(^+)$. Authors believe that dissolved oxygen takes part in direct cathode reaction, rather than serves as depolarizer for atomic hydrogen. Rate of corrosion under natural waters is determined by rate of oxygen diffusion to an effective cathode surface and by protectiveness of film formed on metal. In alkaline solutions, reason for the reduced corrosion is the greater film protectiveness, due to decreased solubility of the rust. There may be a difference in composition between the solution in direct contact with surface of the corroding metal and main solution itself. A saturated solution of ferrous hydroxide is somewhat alkaline and has a pH value of about 9.5. The corrosion of steel by natural waters containing dissolved oxygen is found to be independent of the pH between about 10 and 4.5 at room temperature. **Ferrous Alloys Resistant to Corrosion.** B. D. Saklatwalla. The non-corrosiveness imparted by certain percentages of chromium to steel is more or less dependent on the hardness obtained by heat-treatment. Most generally known non-corrosive high-chromium steel is the so-called "stainless" steel used for cutlery. It contains usually between 12 and 14 per cent chromium and between 0.25 and 0.35 per cent carbon. Decreasing carbon content to less than 0.15 per cent, with chromium unchanged, gives a metal much more resistant to corrosion, and more ductile for general fabricating purposes. Steels with chromium content of 20 per cent, or higher, show remarkable properties of non-scaling at high temperatures and of resisting fresh and salt water corrosion. Nickel steels with about 25 per cent nickel have excellent resistance to mineral acids. To impart acid resistance to chromium steel, 5 to 20 per cent nickel is required. 0.5 to 1.5 per cent copper, added to high-cromium steels, gives them excellent acid-resisting properties.—*John R. Baylis.*

Water Works Distribution Systems. W. E. Macdonald. Can. Eng., **46**: 10, March, 1924. Full discussion, with special reference to design and maintenance.—*N. J. Howard.*

New Filtration Plant for Border Cities. W. Storrie. Can. Eng., **46**: 11, March, 1924. Illustrated description of new plant supplying seven municipalities in vicinity of Windsor, Ont., with capacity of 20 million imperial gallons, and costing approximately $800,000.—*N. J. Howard.*

Rapid Sand Filtration, Cambridge, Mass. G. A. Johnson. Can. Eng., **46**: 12, March, 1924. Details of filter plant recently constructed at Cambridge, Mass. Plant has capacity of 14 million gallons daily and estimated cost of construction is $767,651. Cf. this J., **9**: 5, 824.—*N. J. Howard.*

Various Methods of Making Pipe Connections. Robert W. Angus. Can. Eng., 46: 14, April, 1924. Illustrated article describing various methods of connecting service and drain pipes, waste pipe design, and reservoir connections.—*N. J. Howard.*

Typhoid on Great Lakes Vessels. G. H. Ferguson. Can. Eng., 46: 17, April, 1924. Highest typhoid rate is said to be found amongst sailors and others living on vessels traversing Great Lakes. Water in harbors is seriously polluted and constitutes great danger, if used for either drinking or cooking. Schedule of regulations issued during 1923 by Dominion Dept. of Health for control of such waters is similar to that of U. S. P. H. Service. (See this J., 11: 1, 328.) Examination made in Canada during 1923 of prevailing conditions revealed some unsatisfactory features. In Ontario, only seven ports had facilities for securing water of good quality at wharves. Several boats of Canadian Registry had inadequate provision of water, as judged by normal per capita consumption in Merchant Marine Service. In this regard, it was noted that, invariably, steamships having smallest tank capacities had poorest quality water, as judged by bacteriological standards. On Lake Ontario and the St. Lawrence River, boats are almost entirely of Canadian register; on Lakes Erie and Michigan, of U. S. register; and, on Lakes Huron and Superior, 61 per cent of Canadian register. Statistics relative to typhoid fever aboard Great Lakes vessels of Canadian register, indicate steady increase in number of cases reported between 1920–1923, with abnormally high death rate. —*N. J. Howard.*

Discussion of Water Treatment Problems. Canadian Section of A. W. W. A. Hamilton, Ont. Can. Eng., 46: 20, May, 1924. Discussion upon water works operating conditions, chiefly chlorination, sedimentation and filtration. Valuable information upon chlorine apparatus and control.—*N. J. Howard.*

Laboratory Control in Water Purification. Jack J. Hinman, Junr. Can. Eng., 46: 20, May, 1924. Work of a water laboratory is given in detail. By means of bacteriological examination, quality of treated water can be controlled and public can be warned in cases of emergency. Sanitary and mineral analysis is of value in controlling chemical application and for information of local industrial plants. The analysis of chemicals used in water purification assures uniform quality, while the examination of coal, flue gas, and boiler house supplies aid in maintaining efficiency of plant. Included in work of laboratory would be survey of new sources of supply, supervision of existing sources, study of plant methods, compilation of valuable statistical records, and research in analytical methods. Emphasis is laid upon importance of each laboratory studying its local conditions so that greatest efficiency and economy be maintained, and of correlating unsatisfactory bacteriological tests with certain chemical figures recorded. The application of chlorine and tests for residual chlorine show necessity for constant watchfulness in plant control.—*N. J. Howard.*

Discussion of Water Treatment Problems. Letter by N. J. Howard, Can. Eng., 46–21, May, 1924. Reply to closing discussion reported in previous issue. Has reference to operation of Toronto Plant and to residual chlorine standard of Provincial Board of Health.—*N. J. Howard.*

The New Water System of Marshfield, Wisconsin. F. E. Whittemore. Amer. City, 30: 608–11, 1924. Marshfield, present population 8,000, has had difficulty for 25 years in securing adequate water supply from underground sources. System started with few small wells in 1898. Later, new field of 21 drilled 6-inch wells discharging to common reservoir was provided. Yields were increased by equipping wells with jack-pumps, of type used in oil fields. Then followed experiment with 30-feet concrete well, 70 feet deep, equipped with strainer openings in wall. Later, radial perforated pipes were driven from the pit, without success. Since February, 1924, a new and adequate supply has been provided, consisting of five 30-inch Layne-Bowler wells, having shutter strainers surrounded by introduced gravel. Wells are equipped with centrifugal pumps of 550 g.p.m. capacity, set 50 feet below surface with vertical shaft motor drive. Well pumps discharge to central reservoir from which water is repumped to standpipe and distribution. Special feature of system is automatic electrical control. Float switch in standpipe controls booster pumps, while similar device in collecting reservoir controls individual well pumps successively. Three of the new wells produce 2.0 m.g.d. with 25–30 h.p., as against 0.3 m.g.d. formerly available with 50 h.p. Tests showed one new 30-inch well produced 300 g.p.m. as against 25 g.p.m. by old 6-inch well in same stratum. Water works municipally-owned since 1901.—*W. Donaldson.*

Control of Waste of Water from Fire Service Connections. Amer. City, 30: 616–17, 1924. Report of committee on private fire supplies from public mains, adopted at Annual Convention of National Fire Protection Association, May, 1924. Sources of waste are listed, and recommendations for control, given.—*W. Donaldson.*

The Aftermath of the Berkeley Fire. Carol Aronovici. Amer. City, 30: 626–7, 1924. Editorial note lists among lessons of California fire which destroyed 539 houses with loss of $10,000,000, the following needs relating to water supply: (*a*) Larger mains and better grid-iron; (*b*) Elimination of dead ends and of mains smaller than 6-inch; (*c*) Closer spacing of fire hydrants; minimum of two at congested intersections, and one per block in residential districts.—*W. Donaldson.*

Oxyacetylene Welding and Cutting in a Water Works Department. Anon. Amer. City, 30: 635–6, 1924. Bloomington, Ill., popuation 30,000, consumption 10 m.g.d., finds extensive use for oxyacetylene blow-torch; such as melting lead joints, cutting cast-iron mains, welding fire hydrants, repairing machinery. Much economy is claimed.—*W. Donaldson.*

Water-Main Cleaning in New Albany, Indiana. J. O. Endris. Amer. City, 30: 639–41. 1924. Paper before Indiana Sanitary and Water Supply

Association describes general cleaning carried out in 1922–23 of feeder and distribution systems, consisting of 16-inch pipe and smaller. Some nuusually long shots between cuts were made with cleaning tool. A two-mile stretch of 16-inch pipe was traveled in 40 minutes, bringing out two 5-ton truck loads of rust tubercles. Stretches of 2700, 2200, and 465 feet were cleaned in 12-inch pipe with single operation. Pressure and flow deliveries have been greatly increased, while pipe coatings are stated not to be impaired. Contracts for cleaning additional 6–8 miles have been made. Machine and superintendent are furnished by Cleaning Company; work done by local force. Average cost, all sizes main, was 22 cents per foot. Cleaning has had additional advantage of checking imperfect records as to condition and location of valves, pipe sizes, leaks, etc.—*W. Donaldson.*

Mixed Indicator for Carbonate-Bicarbonate Titrations. S. G. Simpson. Ind. Eng. Chem., 16: 7, 709, July, 1924. Following indicators and procedure have been found superior to the usual phenolpthalein—methyl orange method.

Indicators

Cresol red......0.01 gram + 0.58 ml. 0.05 N NaOH diluted to 25 ml.
Thymol blue (alk. range)
0.03 gram + 1.42 ml. 0.05 N NaOH diluted to 25 ml.
Bromphenol blue
0.02 gram + 0.66 ml. 0.05 N NaOH diluted to 25 ml.

Procedure. Mix 1 volume cresol red with 2 volumes thymol blue solution. Apply 3 drops of mixed indicators and titrate slowly until disappearance of blue has been followed by change from pink to orange-yellow, indicating the neutralization of one-half the normal-carbonate. Apply 4 drops of bromphenol blue and continue titrating until blue changes to green, indicating neutrality. If care is taken in exact preparation and mixing of indicators, highly accurate results are obtainable.—*Linn H. Enslow.*

Effect of Hydrogen Ion Concentration on the Submerged Corrosion of Steel. G. W. Whitman, R. P. Russell and V. J. Altieri, Ind. Eng. Chem., 16: 7, 665, July, 1924. In natural waters, over a fairly wide range, variations in hydrogen-ion concentration have no effect on rate of corrosion. At 22°C., range is pH 10 to 4.1 and, at 40°C., pH 9.0 to 4.3 for the particular oxygen concentrations of waters used. On either side of this zone, rate of corrosion varies very markedly with H. I. C. change. At pH 13, corrosion is extremely low. If pH is reduced by CO_2, as is generally true of natural waters, instead of, as above, by mineral acid, corrosion will increase rapidly below pH 5.4. Decreased rate of corrosion above pH 10 is due to film formation on metal surface. Ferrous hydroxide solution, saturated, has pH = 9.5, but at pH 10, is precipitated and forms film. Rate of corrosion of new steel in natural waters will decrease 50 per cent in one week. From comparing results with CO_2 and HCl, respectively, as sources of acidity, it must be concluded that *total acidity* may be more important than actual *concentration of hydrogen-ions*.—i.e., pH value.—*Linn H. Enslow.*

Constant Temperature, Self Ventilating, Incubator Room: L. D. Felton. Jour. Bact., 9: 2, 169, March, 1924. Constant temperature and constant air circulation are maintained by means of the heating mechanism described. An improvement to the Clark mercury grid thermoregulator is also described. —*Linn H. Enslow.*

Penetration of Bacteria through Capillary Spaces. (II Migration Through Sand). Shields Warren and Stuart Mudd. Jour. Bact., 9: 2, 143, March, 1924. Bacteria will travel rapidly downward through layer of quartz sand submerged under suitable nutrient media. Apparently, rate of penetration, or progress, is dependent upon nature and availability of food present, provided H. I. C. is maintained within proper limits. Maximum rates for migration through quartz sand (average diameter, 0.23 mm.) were for *V Cholerae*, 0.55 cm. per hour; for *V. percolans*, 0.43 cm. per hour. Method is adaptable for separation of motile from non-motile organisms, and also for selection of organisms of highest motility.—*Linn H. Enslow.*

Motility of Bacteria as Affected by Hydrogen-Ion Concentrations. G. Reed and D. J. MacLeod. Jour. Bact., 9: 2, 119, March, 1924. Motility of *B. typhosum* and of *Ps. pyocyanea* in influenced by change in H. I. C. of the medium in essentially the same manner as is growth. Motility of *B. typhosum* has maximum between pH 6.0 and pH 8.0; rapidly decreasing on either side of this zone. Below pH 4.5 and above pH 9.5 no motility is observed. *Ps. pyocyanea* possesses essentially the same characteristics. Results were obtained through observation of the hanging drop at 37°C.—*Linn. H. Enslow.*

Deferrization Plant at the United States Naval Academy, Annapolis, Md. Edward C. Sherman. U. S. Naval Medical Bulletin, 19: 4, 28, October, 1923. Iron removal plant designed and constructed at estimated annual interest and operating cost of $11,000 compared to $50,000 for new surface supply with filtration and chlorination. Best results secured by applying 5 grains lime per gallon to water with limited aeration given by air lift. Precipitation complete in 4½ hours. Twenty p.p.m. iron in raw water reduced to 1.8 by precipitation with lime; further reduced to 0.2 p.p.m. by filters.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Report of Chicago Department of Health, 1922. Typhoid death date of 1.09 per 100,000 was lowest in history of city. Chlorinating equipment in majority of stations was extremely old and often of insufficient capacity to take care of maximum load and leave any units in reserve for an emergency.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Swimming Pools in Detroit—Epidemiological Considerations. Weekly Health Review, Detroit Dept. of Health, November 12–17, 1923. U. S. Naval Medical Bulletin, 20: 2, 271, February, 1924. Twenty-one swimming pools in Detroit have average daily attendance of 5,000. Violet ray has in some instances proven very satisfactory while in other instances it has been unsatisfactory. Pools which are merely emptied and cleaned are not in a sat-

isfactory condition. Authors feel that bacterial standards proposed by Bathing Place Committee of State Sanitary Engineers Conference are too strict and enforcement would close all Detroit pools.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Bathing and Swimming All Year Round in Buffalo Public Schools. John K. Wolfe. J. Am. Asso. for Promoting Hygiene and Public Baths, 5: 47, 1923. There are nine city pools in operation throughout the year. Equipment of pools includes separate dressing rooms, showers and gas or electric hair dryers. Preliminary soap shower bath and inspection by attendant required before bather enters pool.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

The Pollution of Streams and Other Natural Waters of Australia. F. F. Longley. Pamphlet issued by Commonwealth of Australia. General discussion of existing conditions and basic law relative to control of stream pollution. Various phases of pollution discussed are (1) pollution which might render unsafe for human consumption an imperfect municipal water supply, (2) pollution which might put an unreasonable burden on filtration plant, (3) pollution causing nuisance or offence to public decency. Six appendices contain abstracts of English and American literature on stream pollution.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Disposal of Wastes from Gas Plants. Report of 1921 Committee, American Gas Association, New York City. Main portion of report is devoted to tar separator design, attention being devoted to separation of tar from waste water. Milwaukee is cited as having in an experimental way successfully disposed of ammonia-still wastes so that chlorine-phenol tastes were avoided in city water.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Construction of Sanitary Pools. John J. Boyne. J. Am. Asso. for Promoting Hygiene and Public Baths, 5: 39, 1923. Standards adopted by American Association for Promoting Hygiene and Public Baths, in 1915, are considered absolutely essential in construction and maintenance of a sanitary swimming pool. Designer must be alive to large amounts of impurities carried into the pool and to the dangers of absorbent pool linings. Essential differences exist between real and apparent cleanliness.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Annual Report, 1923, Bureau of Sanitary Engineering, Maryland State Department of Health. Brief accounts are given of public water works and sewerage improvements and installations in the state. Stream pollution investigations include Curtis Bay where improvements were made to prevent pollution by wastes from oil and asphalt refining plants, a chemical company, tannery, industrial alcohol plant and Baltimore City sewage. Other investigations are of wastes from a congoleum plant; steel rolling mill; garbage reduction plant; creamery; chenopodium plant and canning factories.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Report of Rhode Island Board of Purification of Waters for the Year 1922. Preliminary Report of An Investigation of the Pollution of Certain Rhode Island Public Waters. Stephen DeM. Gage and Philip C. McGouldrick. Methods by which pollution by oil has been checked are described and activities of board relative to reducing pollution by sewage and trade wastes are outlined. About half of drainage area of streams discharging through Rhode Island lies outside the state. It is estimated that about seven times normal flow of Moshassuck River would be required to properly dilute the sewage and industrial wastes now discharged into it.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Oxygen in Its Relation to Pure Water. Geo. W. Colles. Southwest Water Works Journal, 5: 12, 11, March, 1924. Author advocates aeration of waters generally, especially those containing organic matter, either as the sole treatment or preliminary to other forms of purification. *A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Water Consumption in Chatham. C. H. R. Fuller. Canadian Engineer, **46**: 9, 287, February 26, 1924. Average amount of water pumped was 1,514,603 gallons per day. Double coagulation with alum commenced during the year resulted in a water much better prepared for final treatment by chlorination than heretofore produced during summer months.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Water Purification—Biochemical Factors in Modern Methods. Dr. Gilbert J. Fowler. Local Self-Government Gazette, **9**: 11, 571, November, 1923. Growth of minute algae in storage reservoir is discussed. Suggested that a coagulant, preferably aluminum salts, be added to water, followed by lime to remove carbon dioxide. In absence of carbon dioxide photosynthesis cannot go on and algae growth is checked. Yangtsze River which flows through plains heavily manured with sewage but shows slight signs of pollution due to the water being heavily charged with fine silt, is cited as indicating possibility of purifying water by means of the drifting sand filters.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Status of Water Supplies in Quebec. Theo. J. Lafreniere. Canadian Engineer, **46**: 9, 273, February 26, 1924. City of Quebec derives its supply from St. Charles River without treatment. St. Jerome experienced danger of connection with an industrial supply. During fire prevention week connection was opened twice at intervals of 7 days for 1 hour each time. Mild typhoid epidemic resulted, with characteristics of a water-borne outbreak and two summits in curve at 7 day intervals.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

On the Cause and Prevention of the Loss of Carrying Power of the Colombo (Ceylon) Water Mains. L. F. Hirst. Reports of Medical Officer of Health for 1921 and 1922. Laboratory and field tests to determine cause of incrustation of iron water pipes are described. 1.5 p.p.m. to 8.0 p.p.m. iron in fer-

rous and ferric state, sulphur, and iron bacteria, as Leptothrix ochrea, are present in water. Chlorine in amounts over 5 p.p.m. and lime to amounts over 4 g.p.g. proved effective in killing bacteria but did not prevent incrustation. Coke aerator, sedimentation basin and slow sand filters used to prevent incrustations.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Cleethorpes Bathing Pool. Surveyor, **65**: 1678, 287, March 14, 1924. Pool is D-shaped and has maximum length and width of 400 and 200 feet respectively. Filter chamber for filtering sea water and reservoir for storage of filtered water have been provided.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Report of Committee of Royal Sanitary Institute of Purification of Water of Swimming Baths. Journ. Royal Sanitary Institute, **44**: 11, 451, April, 1924. From economic viewpoint filtration and aeration are better than daily refilling pool. Even with this treatment, pool should be cleaned and refilled every 4 to 6 weeks in summer.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

50th Annual Report Water Commissioners, Springfield Mass., 1923. In 1923, 22,000 Scotch pine trees were planted making a total of 309,200 trees of different species planted in reforestation of watershed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Inverse Relation Between Iodin in Food and Drink and Goiter Simple and Exophthalmic. J. F. McClendon and Joseph C. Hathaway. J. Am. Med. Assoc., **82**: 21, 1668, May 24, 1924. Iodin content of various foods and waters in goitrous and nongoitrous regions. Milk, leafy vegetables and some fruits contain the highest amount of iodin of any land products. Three day experiments with diet of certain foods showed a retention of 0.036 mg. iodin. At this rate 10 years would be required to accumulate 40 mg. of iodin the amount contained in a normal thyroid gland. Table of iodin content of drinking waters show highest to be 18,470 times as great as lowest. Treating with one-tenth pound sodium iodid per million gallons of water would give a content one-fifth to one-tenth that of some cities of this country and assuming a liter of water to be consumed per day, 0.01 mg. of iodin, which is the normal quantity retained by a person, would be retained and the iodine requirements would be satisfied.—*A. W. Blohm.*

Conical Bottom Tanks for Water Treatment. R. C. Bardwell. Railway Eng. and Maintenance, **19**: 339, 1923. Claims economies in water saving from the sludging of conical bottom treating tanks as quoted by Knowles (CA **17**: 3066) are exaggerated.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

New Rock Island Water Station Saves Over $12,000, Annually. Anon. Railway Eng. and Maintenance, **19**: 346, 1923. Location—Chickasha, Okla. Water of varying quality is pumped from 10 shallow 8-inch wells 600 feet apart into central reservoir, replacing 10 closely spaced 4-inch wells. Each is served by separate electric motor unit. Chemical treatment takes place continuously in a 30 feet diameter by 60 feet high steel tank in which is pro-

vided 6 hours sedimentation period with no filter. Proportioning is controlled by chemical pump geared to transfer pump. Increasing agitation in downtake tube aided softening reactions. Better and cheaper water is secured. Prints and plans are shown.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Two Railroads Find Water Pipe Cleaning Profitable. Anon. Railway Eng. and Maintenance, 20: 64, 1924. Photographs and description of method, together with tabulation of economies, are given for pipe cleaning work performed by Northern Pacific RR., at Dilworth, Minn., and by the C. R. I. & P. RR., at Chickasha, Okla.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Remodeled Plant Solves Mud Problem. C. R. Knowles. Railway Eng. and Maintenance, 20: 4, 1924. At the Baton Rouge, Miss., terminal of Illinois Central RR. old 12,000 gallon sedimentation tank was supplemented with two 100,000 gallon conical bottom steel tanks which aided materially in removing the Red River mud from Mississippi River water.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Santa Fe Builds New Water Station Where Supply is Limited. E. H. Olsen. Railway Eng. and Maintenance, 20: 266, 1924. The A. T. & S. F. Railroad installed a 550 g.p.m. pumping plant from the Cottonwood River at Bagar, Kansas, consisting of triplex pump driven by oil engine taking water from collecting sump. Treating equipment consists of 10 x 12 Roberts water engine with 24 feet x 63 feet settling tank and 30 feet x 60 feet storage. An earth dam 2600 feet long by 28 feet maximum height impounds 14,000,000 gallons water. Photographs and detail plans are given.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

New Pumping and Softening Plant is Electrical Throughout. C. R. Knowles, Railway Eng. and Maintenance, 20: 233, 1924. Railway Review, 74: 958, 1924. Illinois Central secures its water supply at Clinton, Illinois, from three wells 350 feet deep. Water is pumped into reservoir with vertical centrifugal pumps; thence it is pumped through continuous treating plant of the Jos. E. Nelson design with gravity type sand filters. All units are electrically driven and equipped with recording gauges. Treating tanks are conical bottom type. Photographs and general layout plan is given.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Standard Methods of Water Analysis. Com. report, Railway Review, 74: 559, 1924. A. R. E. A. Bulletin 261: proc. 1924. Standard methods for field tests, rapid boiler water method, and full and complete analysis were adopted for recommended practice at 1924 convention of A. R. E. A., together with interpretation of results.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Government Regulation of Railway Drinking Water Supply. Com. report, Railway Review, 74: 563, 1924. A. R. E. A. Bulletin 261: proc. 1924. Status of regulations pertaining to railway drinking water is outlined. Statement

is made that no adverse physiological effects have been noted on persons drinking lime and soda ash overtreated water.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Effect of Water Conditions Upon Lengthened Locomotive Runs. L. F. Wilson. Railway Review, 74: 848, 1923. Use of anti-foaming compound is recommended as assistance in operating locomotives on long runs.—*R. C. Bardwell.* (*Courtesy Chem. Absts.*)

New Engine Terminal at Peach Creek, W. Va. Anon. Railway Review, 74: 279, 1924. Description of new pumping station covers installation of duplicate electrically driven horizontal centrifugal pumps in dry well 35 feet deep. Sixty thousand gallon per hour treating plant consists of International Filter Company proportioner with 40 feet x 53 feet sedimentation and storage tank, equipped with floating outlet. Detailed plans and photographs are given.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

The Value of Treated Water for Locomotives. Com. report, A. R. E.A. Bulletin, 261: 167, 1924. Progress report.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Pitting and Corrosion of Boiler Tubes and Sheets. Com. report., A. R. E. A. Bulletin, 261: 164, 1924. Progress report. Full explanation of hydrogen ion concentration and interpretation given. *R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Meters and Their Selection for Specific Purposes. Thomas H. Hooper. Fire & Water Eng., 74: 447, September 5, 1923. Very brief descriptions of velocity, disc, and positive oscillating piston types of meters. First cost, or initial efficiency, should never enter into selection of meters, but rather maintained accuracy, ease of repairs, and amount of repairs necessary.—*Geo. C. Bunker.*

How Filters Should Be Cared for in Wintry Weather. Michael F. Collins. Fire & Water Eng., 74: 501, September 12, 1923. Brief remarks on the difficulties of operating open slow sand filters, at Lawrence, Mass., in the winter seasons, due to snow falls and ice formations. Illus.—*Geo. C. Bunker.*

A Novel Well Water Fire Protection System. H. C. Wetmore. Fire & Water Eng., 74: 505, September 12, 1923. Salt water wells, the depths varying from 40 to 50 feet, have been drilled on street corners, in the various sections of Key West, Fla., by a No. T-32 Star drilling machine, of tractor type, with 12-inch drill. Hydrants carrying a 4-inch cast iron suction pipe 24 feet long are set in sidewalk over wells. Capacity of each well is about 1000 gallons per minute; cost, complete with hydrant, varies from $75 to $100. Well installation of this kind is more economical for any small city in low-lying section of the country than system of street mains. Patent has been applied for. Illus.—*Geo. C. Bunker.*

Cost Problems That Confront the Water Department. CALEB M. SAVILLE. Fire & Water Eng., **74**: 507, September 12, 1923. Main pipe extensions are now financed by making assessments against properties benefited. Statistics are given to show growth of water supply system of Hartford, Conn. Two diagrams contain data concerning (1) main pipe construction and wages; and (2) distribution construction work. Pipe laying costs for mains of 6-, 8-, 10-, 12-, and 16-inch diameters, as laid in 1922, are compared with those of previous years, 1915–1921. Of 65,800 feet of main pipes laid in 1922, 35,638 feet were laid with Keystone trenching machine at average saving of about 40 cents per foot. Costs of pipe laying by machine and hand labor are compared in table. For service pipes installed during 1922, black wrought iron pipe, 1¼ inch, lined with cement, had been used. Pipe costs 13 cents per foot, and lining, 4 cents; a total of 17 cents, as compared with 14 cents per foot for 1-inch-galvanized iron pipe which had been used previously. Lead lined fittings used in connecting up the service pipes are made by regular employees during winter months. Due to breakages of lead "goose necks," these have not been used for several years; sufficient flexibility is given to connection by using two elbows. Ordinary service consists of 3-inch brass corporation cock with 1½ inch outlet, male thread, screwed into main, and connected by 1¼-inch lead-lined elbow and 1¼-inch street ell to 1¼-inch black wrought iron pipe lined with cement. This pipe is in turn connected, by means of 1¼-inch lead lined coupling, to 1-inch brass curb cock with 1¼-inch male ends. About one-fifth of all water filtered and dispatched to city returns no income; this amounts to 2.5 to 3 million gallons per day which may be fairly allocated as follows: under-registration of meters, 1,000,000 g.p.d.; leakage in mains and services, 1,250,000 g.p.d.; miscellaneous use of water, including fire, sewer flushing, public fountains, and surreptitious use, 500,000 g.p.d. Leakage from mains and services, if correct, is probably too widely distributed over system for profitable elimination. Under-registration comes from installing meters of size too large to register at lower flows. Some remedy can be had by closer attention to sizing of meters for particular locations; but best control is by establishing excess capacity charge for meters in excess of normal size. A diagram gives comparison of rates with those of 8 other cities.—*Geo. C. Bunker.*

The Task of Raising Fire Hydrants to Meet New Grade Level. CHARLES W. GEIGER. Fire & Water Eng., **74**: 509, September 12, 1923. Description of methods used by Fire Department in San Francisco, Cal., in raising of 37 fire hydrants on lower Market Street, made necessary by subsidence of land. Illus.—*Geo. C. Bunker.*

A Seasoned Water Works Man Gives Some Practical Advice. FRANCIS H. LUCE. Fire & Water Eng., **74**: 511, September 12, 1924. Practical suggestions for superintending development and growth of a small water works system; insertion of valves without shut-off; meeting emergencies of peak load; protection and care of hydrants; minimizing trouble from installation of sewers; resetting valve boxes during asphalting of streets.—*Geo. C. Bunker.*

Fire Hose Used in Emergency to Relieve Water Shortage. George W. Batchelder. Fire & Water Eng., 74: 536, September 12, 1923. Brief account of how Shrewsbury, Mass., was supplied with water through fire hose connected to hydrants on Worcester side of Lake Quinsigamond, until additional wells drilled, to provide temporary relief.—*Geo. C. Bunker.*

Water Works Rules Should Receive Careful Thought. William W. Brush. Fire & Water Eng., 74: 503, September 12, and 585, September 19, 1923. Of 126 rules and regulations made effective in New York City on August 1, 1923, 122 are given, with explanations added, and some hints to superintendents. They are presented in following order: *General Rules*: Independent water supply; Shut-off charges; Use of hydrants; Deviation from rules. *Permits:* General permits; Permittees; *Taps:* Separate supply; Method of tapping; spacing of taps; Plugs; Electrical indicator; Size and number of unmetered taps; size; *Flushometers and part business*; Roof-tank or pump supply; Size of metered taps; Fire connections; Size of excavations; Service pipes; *Piping;* Dimensions and weights; Brass services; High pressure services; Wiped joints; Valves; Curb cocks; Service to be straight; Goose-necks; Depth of service; Tests; Minimum and maximum diameters; Minimum size of goose-neck; Size of service for domestic consumption; Check valves; Thawing; Elimination of private mains, driven taps, and transferring of taps and services; *Meters:* Setting of meters; Pits; Current meter setting; Minimum and maximum size; Reduction of size of meter; fire lines; Fire line consumption. Tables and diagrams are included.—*Geo. C. Bunker.*

Determining the Yield of Underground Water Sources. Waldo S. Coulter. Fire & Water Eng., 74: 581, September 19, 1923. General remarks, including three diagrams to illustrate points made.—*Geo. C. Bunker.*

The Watershed and Its Proper Care. Frederic I. Winslow. Fire & Water Eng., 74: 629, September 26, 1923. To control a watershed, a large area around perimeter of main supply reservoir should be obtained. Some variety of pine is recommended as best type of tree for planting on New England watersheds; importance of spraying the trees and of taking certain precautions re fire prevention is pointed out. General remarks are made on following subjects: regulation of sources of pollution; inspection and protection of dams; care of culverts; rain-gages; cleaning of aqueducts; filtering and chlorinating street wash; utilization of power in generating electricity; regulation of outflow; "floating" of under-reservoir pipe lines; importance of chlorination. .—*Geo C. Bunker.*

Should Fire Hydrants Have 4½-inch Outlets? Frank A. Marston. Fire & Water Eng., 74: 675, October 3, 1923. Conclusions are as follows: (1) Use of 4½-inch steamer outlets on hydrants, in addition to two 2½-inch hose outlets, is desirable where pumping engines are likely to be used. In larger cities, it is probably better to provide two large steamer outlets and only one 2½-inch outlet. (2) Trend of good practice appears to be toward reduction of pressure maintained in distribution systems to provide for domestic service,

with dependence on fire department pumping apparatus for fire stream pressures. (3) Steamer outlets should be provided even where ordinary pressure is ample for two hose streams, to make possible the draft of water at higher rates with pumping engine, in case of serious fire, or other emergency. (4) Distribution system should be capable of delivering water to hydrants at rates consistent with demands of modern fire fighting methods. (5) During a serious fire, hydrants may be subjected to considerable vibration due to heavy drafts of water. To prevent failure at such a critical time, hydrants should be of heavy construction and firmly supported. Special precautions should be taken to prevent blowing off of hydrant from lateral at base. (6) According to underwriters' rating, municipality will be penalized for deficiency in steamer outlets, where engine service is required. (7) It is desirable to install steamer outlets even where pressure of 75 pounds per square inch is ordinarily maintained, to provide for engine service in emergency. (8) There appear to be several good reasons in favor of providing at least one large steamer outlet on every hydrant in a standard pressure water distribution system; and no valid reason to the contrary.—*Geo. C. Bunker.*

Sinking Funds Set Aside for Retirement of Water Bonds. ERNEST C. WILLARD. Fire & Water Eng., **74**: 696, October 3, 1923. Article based on recent report on water works of Portland, Oregon. Source of water is Bull Run Lake, located in Bull Run division of Oregon National forest, watershed area being 222 square miles. Bull Run river runs for about 22 miles to headworks, from which water flows by gravity into six reservoirs through two conduits. Conduit No. 1 consists of 24.29 miles of riveted steel pipe, laid in 1893, of three sizes, 33, 35, and 42 inch. Conduit No. 2 consists of 24.79 miles of lock bar steel pipe, laid in 1910, of two sizes, 44 and 52 inch. From reservoirs, water is either pumped, or delivered by gravity, to the various distributing points. Total mileage of mains in distribution system is 1036: of which 66 are privately owned. Water requires no chemical treatment of any kind, and is soft. Sinking fund has been established for retirement of approximately $7,538,000 bonds, and actuarial tables were compiled for each of outstanding bond issues, together with summary table, showing total amount that should be set aside each year and amount that should be on hand at end of each fiscal year for all of bond issues. In determining amount of revenue necessary, it was decided that 22.1 per cent was attributable to fire protection, and 77.9 per cent to consumption. Eighty per cent meterization was suggested in order to reduce average daily consumption by at least 20 per cent. Perpetual inventory and new accounting system were recommended and adopted.—*Geo. C. Bunker.*

Laying a Submarine Pipe Line. HARRY U. FULLER. Fire & Water Eng., **74**: 724, October 10, 1923. Detailed illus. description of laying of submarine pipe line from Portland, Me., under harbor to South Portland. Contract consisted of moving two submarine electric power cables, dredging a trench and laying 1000 feet of 16-inch cast-iron pipe (class D, A. W. W. Assoc. specifications), backfilling with cover of 3 feet, and trenching and laying section of about 70 feet in length of 16-inch pipe at each approach to submarine line to connect with the existing pipe lines. Depth of water was 35 feet at low tide

in channel. Contract was let to the lowest bidder for $11,400 which did not include pipe. Every third joint was flexible, of improved metropolitan type in which lead is held firmly by grooves to bell of the pipe, motion being between spigot and lead joint. Specifications required that leakage should not exceed 16.8 gallons per joint per 24 hours for submarine joints, and 8.4 gallons for land joints, under pressure of 150 pounds. The third test during construction showed leakage of 2540 gallons per day, or $\frac{6}{10}$ times allowable leakage. No attempt was made to caulk joints under water. Several months after pipe line was completed, test with meter showed that leakage was negligible. Actual costs are summarized as follows: dredging trench, $2.00 per linear foot; laying submarine pipe, $5.00 per linear foot; backfilling submarine trench, $0.75 per linear foot. Contractor did not make a profit proportional to his risk; or, in other words, contract price was too low.—*Geo. C. Bunker.*

Gravity Water Systems Predominate in Vermont. C. P. Moat. Fire & Water Eng., **74**: 727, October 10, 1923. One-hundred and six supplies of cities, towns and villages have been classed as public water supplies, of which sources are as follows: surface, 31; ground, 60; both surface and ground, 15. Of these, 56 are classed as normal waters; 23, as having received satisfactory natural purification; and 3, as unsafe. Only supplies being treated at present time are those of Burlington, filtration and chlorination; St. Johnsbury, slow sand filtration; Rutland and Montpelier, chlorination. Brief descriptions of supplies of the 21 cities and large towns are given and also table with typical analyses of the public water supplies.—*Geo. C. Bunker.*

Composite Type Dam at Bassano, Alberta. Eng. Contrg., **62**: 336, 1924. This is a composite dam of earth and spillway of Ambursen type, costing $1,500,000.00.—*Langdon Pearse.*

Why Chicago Needs Universal Meterage. John Ericson. Eng. Contrg., **62**: 337–9, 1924.—*Langdon Pearse.*

Handling Silt in Settling Basins. Roy M. Towl. Eng. Contrg., **62**: 341–4, 1924.—*Langdon Pearse.*

Design Features of Recent Swedish Arch Dams. B. Hellstrom. World Power Conference London, 1924. Eng. Contrg., **62**: 345–7. Details construction and design; also describes refacing old dam with concrete.—*Langdon Pearse.*

Prices of Water Works and Others Materials. D. H. Maury. Eng. Contrg. **61**: 1039–43, 1924. Lists pipe, lead, structural shape, reinforcing, portland cement, brick, lumber, fuel oil, tile pipe, copper, coal, month by month, 1921 to 1924, cast iron 1902 to 1924.—*Langdon Pearse.*

Installing Services for Vacant Lots in Advance of Paving. Eng. Contrg., **61**: 1044–5, 1924. Practice is given of 8 cities.—*Langdon Pearse.*

Portable Air Compressors in Water Works Service. Eng. Contrg., 61: 1046–7, 1924.—*Langdon Pearse.*

Cost of 48-inch and 36-inch Mains at New Bedford, Mass. S. H. Taylor. Ann. Rep. Water Board, 1923. Eng. Contrg., 61: 1060, 1924. Forty-eight-inch cost $26.34 per linear foot, 36-inch $23.81.—*Langdon Pearse.*

Sacramento Filter Plant Pumping Station. Albert Gwan. Eng. Contrg., 61: 89–91, 1924. Is built in a 75-foot diameter concrete caisson. Low lift and high lift centrifugals are provided, driven by squirrel cage motors. Mechanical and electrical details are described.—*Langdon Pearse.*

Construction Features of Reservoir at Grand Junction, Col. Eng. Contrg., 61: 75–6, 1924. General details are given of a 13,500,000 gallon reservoir with reinforced concrete lining 6-inch thick, laid in 2 layers, 4- and 2-inch respectively, on earth slope.—*Langdon Pearse.*

Financing Service and Supply Main Extensions by Local Assessment. P. Diederick. Calif. Sect. Am. W. W. Assn., 1923; Eng. Contrg., 61: 77, 1924. All mains not over 4-inch are paid for by assessment per front foot.—*Langdon Pearse.*

California Reclamation District No. 2047. S. E. Gamble. Eng. Contrg., 61: 78–81, 1924. Describes pumping equipment for handling 200,000 acres.—*Langdon Pearse.*

Well Water System of Auburndale, Florida. H. C. Hewitt. Pub. Works, 55: 119, 1924. Well was lined with 10-inch casing for 136 feet depth, with 40 feet strainer in sand formation below. This secures a softer water.—*Langdon Pearse.*

Danvers Water Works Notes. R. W. Estey. Pub. Works, 55: 175, 1924. While cement lined pipe is still in service, some since 1876, cast iron is being used to replace it. A meter program is found necessary.—*Langdon Pearse.*

Water Works Statistics. Pub. Works, 55: 141–2, 161–174, 1924. Notes are given on street main laid, pressures and pumping plants in many United States cities. Data very general in character.—*Langdon Pearse.*

Pressure in Water Mains. Pub. Works, 55: 159–60, 1924. Averages are given for about 600 cities, showing maximum and minimum by states.—*Langdon Pearse.*

Pumping at Putnam, Conn. C. D. Sharpe. Pub. Works, 55: 143, 1924. Water power serves ordinarily to pump about 1.2 million gallon per 24 hour. Steam (coal at $11.00 per ton) is slightly more expensive than electric pumping (current at 2.6 cents per kilowatt hour.)—*Langdon Pearse.*

Elmhurst's Oil Engine Plant. H. S. Crockett. Pub. Works, **55:** 143–4, 1924. Diesel oil engine is used to drive both centrifugal pump and air compressor. Is of 4 cycle type, delivering 93 b.h.p. with not more than 0.45 pound oil per b.h.p. at full load.—*Langdon Pearse.*

New Bedford Water Works Notes. Pub. Works, **55:** 146, 1924. To keep down number of pipe extensions, all petitions must guarantee income from line of 6 per cent on estimated cost of laying, based on previous year costs.—*Langdon Pearse.*

Change from Flat Rates to Meter made Savings. W. R. Davis. Fire and Water Eng., December 5, 1923. Eng. Contrg., **61:** 92–3, 1924. Clifton, Arizona, saved 50 per cent of the water by change to meter rates.—*Langdon Pearse.*

A Large English Bored Well. F. J. Dixon. Inst Water Engr., 1923; Eng. Contrg., **61:** 347–53, 1924. Details sinking, lining and testing of 1054 foot hole, in 36 to 20 inches diameter sections, also pumping plant; centrifugal pump in well being driven by Diesel engine.—*Langdon Pearse.*

The Suorva Lakes Dams, Lapland. Engineering, December 14, 1923: Eng. Contrg., **61:** 361–8, 1924. Dams are of multiple arch type, of reinforced concrete. Details are given.—*Langdon Pearse.*

Diamond Drilling under Difficulties. R. P. McGrath. Mine and Quarry, November, 1923; Eng. Contrg., **61:** 95–99, 1924. Describes 3 jobs on western rivers.—*Langdon Pearse.*

Installation of Check Valves on Water Services. C. B. Jackson. Calif. Sect. Am. W. W. Asso., October, 1923; Eng. Contrg., **61:** 100–2, 1924. Discusses legal aspects of putting check valve between hot water heater and boiler.—*Langdon Pearse.*

Method of Repairing Concrete Reservoir. Successful Methods; Eng. Contrg. **61:** 118–9, 1924. Roofing felt laid. Pitch was held in place by brick wall.—*Langdon Pearse.*

The Hartebeestport Dam, Pretoria, South Africa. Eng. Contrg., **61:** 340–2, 1924. Arch dam, of concrete; base width, 73-feet; maximum height, 172 feet. Spillway is cut as a trough.—*Langdon Pearse.*

Responsibility of the Water Works Superintendent. J. Martin. Eng. Contrg., **61:** 369–71, 1924. Duties and methods of securing cooperation of public are outlined.—*Langdon Pearse.*

The New Water Works Pumping Plant for Tully, N. Y. Louis Mitchell. Eng. Contrg., **61:** 372–4, 1924. Describes equipment for village, 600 population, with details and costs.—*Langdon Pearse.*

Failure of the Gleno Dam in Italy. Giovanni Rodio. Eng. Contrg., **61**: 375–8, 1924. Concrete gravity dam, built to 75 feet height, was finished as multiple arch to additional height of 95 feet. Middle portion failed, largely due to inadequate construction methods.—*Langdon Pearse.*

How Local Conditions Affect Cost of Construction of Water Works. R. Messer. League Va. Municipalities, 1924; Eng. Contrg., **61**: 379–80, 1924. Newcastle, Va., put in waterworks for $14.25 per capita, whereas St. Paul, Va., works cost $70 per capita.—*Langdon Pearse.*

Announcement

THE Journal of the American Water Works Association has been published each month since September, 1924. In the future this monthly issuance will be continued. Two volumes of the Journal, consisting of six monthly issues in each volume, will be prepared each year. The increased number of Journals should meet the requirements of members and advertisers in a more satisfactory degree than in the past

ABEL WOLMAN, *Editor*

By Authority of the Publication Committee

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

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Discussion of all papers is invited

VOL. 12 DECEMBER, 1924 No. 4

OPERATING EXPERIENCES AND ECONOMY OF A DIESEL ENGINE DRIVEN PUMPING STATION[1]

BY W. DEWITT VOSBURY[2]

A Diesel engine driven pumping station is a comparatively new idea in water works practice. Whether or not this type of plant has come to stay depends, in great measure, upon two principal factors: namely, reliability and economy. Reliability has been fairly well demonstrated by the successful and rapidly increasing application of internal combustion engines to the propulsion of ships.

The efficiency of Diesel engines is well known. It is not generally recognized, however, that this engine differs from steam as a source of power in that the efficiency of a unit is independent of its size. In other words, approximately the same thermal efficiency is gained from Diesel engines regardless of the indicated horse power, whereas large units are necessary for maximum efficiency with steam. For moderate size pumping stations, Diesel engines, therefore, have an advantage over the latter as a source of power.

In considering the over-all economy of the Diesel engine for pumping purposes it is necessary to take into consideration such factors as the relatively high capital cost, maintenance, load factors and the cost of power from other sources. All of these considerations were carefully weighed before the adoption of Diesel engines for the new pumping station at Gloucester, New Jersey; the operation and economy of which will presently be described.

[1] Presented before the New York Convention, May 23, 1924.

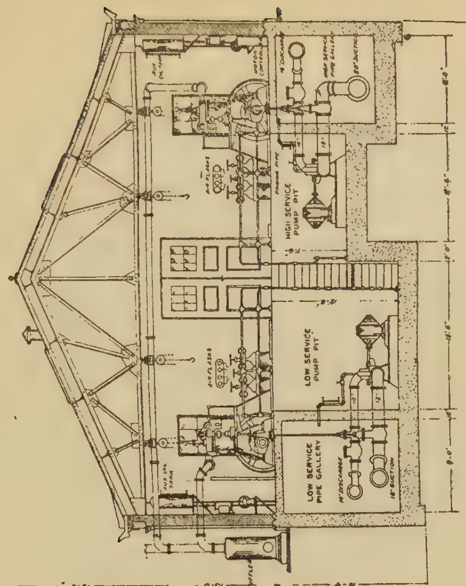
[2] Consulting Engineer, Camden, N. J.

The original plant had a capacity of 2,000,000 gallons per day. It was steam driven and constructed in 1883. Water was raised by compressed air from approximately twenty driven wells and discharged into a receiving basin. From the latter it was pumped to an iron removal plant consisting of an aerator and sand filters. After filtration it was pumped for the third time into the distribution system. Most of the equipment was inefficient and badly in need of repair or replacement. As a consequence operating expenses were excessive, amounting in 1921 to $36,000. In addition, the supply of water was inadequate. It was clear, therefore, that in remedying the situation, any general scheme of improvement should first recognize the necessity for an ample supply of water and, second, a reduction in operating expenses.

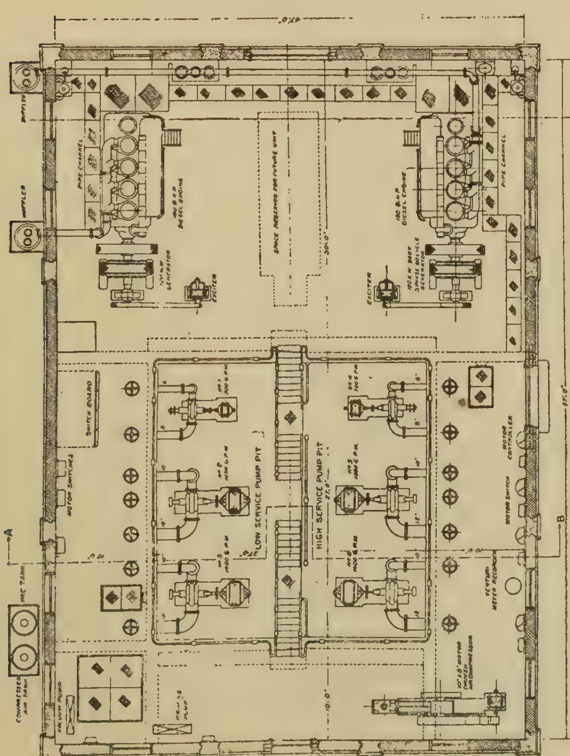
From a series of tests it was determined that with six to eight wells of a new type, it would be entirely feasible to pump all water required by direct suction at a maximum draft below the ground surface of not exceeding 30 feet. It was, therefore, decided to lift the water from the wells to the filter plant by pumps installed in a suitable pit. Owing to the depth of the pit required, it was desired to keep it as small as possible to avoid excessive construction costs. The practical limits of the pit eliminated the use of high duty pumping engines. Steam, turbine-driven, centrifugal pumps were considered. It was found, however, that they could not be used, due to low power requirements and consequent necessity of operating them without condensers. Further investigation, which took into consideration the necessity of replacing all old equipment, as well as economy in first cost and efficiency in operation, led to the decision to adopt motorized centrifugal pumps and to construct an entirely new, electrically-driven pumping station. Following this the cost of current from other sources, together with the capital cost of a standby unit, was compared with the cost of current generated by high-economy, internal-combustion engines. The comparison was found to be in favor of the latter. Full-type Diesel engines, direct connected to generators were therefore adopted as prime movers.

The new plant was completed and placed in operation in September, 1922. It has a pumping capacity of four million gallons per day. The power and pumping equipment consists of two Diesel engine-driven generating units; three low-lift and three high-lift horizontal, single stage, centrifugal pumps; a compressor for furnishing air under pressure to clean the wells and two vacuum pumps for main-

ELEVATION
SECTION A-B



PLAN OF STATION



taining a constant vacuum on the suction line. The pumps and compressors are motor driven.

The generating units are located at one end of the building with sufficient space between for the installation of a third engine when required. Each unit consists of a 180 h.p., vertical, four cylinder, full-type Diesel oil engine, direct connected to a 120 kw, revolving-field generator. The engines operate at 300 r.p.m. Three phase, 60-cycle, 240-volt current is used. Storage for fuel oil is provided by two 11,000 gallon tanks buried in the ground outside of the building. The oil is pumped by hand, as required, from the storage tanks to two small tanks, one of which is located on the wall back of each engine. From the latter it flows by gravity and is injected into the cylinders by air under a pressure of from 60 to 70 atmospheres.

As before stated, there are two sets of pumps; one for low-service from the wells to the filter plant; the other for high-service from the clear water reservoir to the distribution system. Each set consists of three pumps having a capacity of one, one and one-half and two million gallons per day respectively. This combination of capacities provides pumping rates of from one to 4.5 million gallons per day at intervals approximating 500,000 gallons. The two largest pumps of each set are inter-connected for operation in tandem whereby the discharge pressure can be doubled.

Both sets of pumps are located in a pit which is 27 feet square and of two depths; the deeper half being occupied by the low-service pumps. At opposite sides of the pit are galleries in which the rather complicated piping is concealed. Operation of valves and pumps is controlled from the floor above, so that it is not necessary to enter the pit except for inspection and oiling.

It was natural to surmise that some difficulty would be experienced in starting up a plant of this type. The expected difficulties failed to materialize, however, while others which had been entirely unforeseen gave a great deal of trouble. The old station had a crew of fifteen men consisting of firemen, oilers and steam engineers with no experience whatsoever in the operation of either Diesel engines or electrical equipment. For certain reasons no radical change in personnel could be made. Seven men were, therefore, selected from those available and placed in charge of the new plant. This was done without their having had any previous training or experience other than that gained while the engines were being tried out and tested.

When the station was first placed in service the men had considerable difficulty in changing over from one pump to another, or in placing an additional pump in operation. This was due to the load increasing much more rapidly than the engine could handle it. As a result there would be a sudden drop in voltage, following which the pump speed would be reduced. The reduction in speed would often reach the point where either or both pumps would drop their suction.

The engines were guaranteed to operate from no load to full rated capacity without exceeding 3 per cent each way from mean speed, providing the change in load was not made too rapidly. A method of gradually building up the load or its equivalent was finally worked out. This consists in first priming the pump to be placed in operation. The motor is then started and gradually brought to speed during which the discharge valve is slowly opened and the voltage adjusted at the switch board. The whole operation requires from one to two minutes, depending upon the increase in power consumption and the proportion which it bears to the total load.

During the first few weeks the most serious situation encountered was the entire lack of confidence which the men had in the reliability of the plant. Primarily they were steam engineers and, as such, they viewed any change from the old order of things as one to be looked upon with distrust. In addition, there were more men in the old plant than could be used in the new. Some were sure to lose their positions and they did not hesitate to circulate rumors which eventually gained a foothold with the public. So strong became the general belief that the new plant would prove to be unreliable, it was decided not to dismantle the old station but to hold it in reserve against the day required. Unfortunately for the reputation of the old plant, this day came all too soon. A final change was necessary in the main discharge piping between the two stations. While under way it was decided to shut down the new station and run the old. Much to the surprise and chagrin of the supporters of the old plant it was found that it could not be run. Like the famous one-hoss shay, it had outlived its useful life and collapsed beyond repair. With its passing went all lack of confidence in the new station. It had to be run and it did run. During the period of twenty months which has elapsed since that time no shut-down has occurred; the supply of water has been ample; the pressure has been constant and the men who operate the plant now have entire confidence in it.

Of the two engines one only has given any trouble. This took the form of frequent changes in speed which appeared to be fairly periodical and affected the pumps in the manner already described. Each time this engine was placed in operation it would run at constant speed for a period of time, varying from a few hours to several days. Periodical fluctuations in speed would then begin to occur with increasing frequency until it would finally become necessary to shut the engine down for overhauling. Upon pulling out the exhaust valves they were always found to be heavily carbonized and badly in need of regrinding. It was thought at first that the trouble was due to some defect in the governor. It was finally traced, however, to the collection of very minute particles of sand and scale on the seat of the fuel oil pump which regulates the quantity of oil injected into the cylinders at each stroke. The presence of the foreign matter was a mystery. Apparently every precaution had been taken to prevent just such an occurrence. The fuel supply lines had all been carefully washed out and drained. The oil itself had been tested for suspended matter. There was also a standard make of strainer through which all oil had to pass before reaching the engine.

After a great deal of experimenting, the source of the scale was located in the oil piping of seamless, drawn, steel tubing and was due to the fact that the pipe had not been pickled. The fine grit came from the interior of the gravity tank where it was found adhering to the galvanized surfaces. The filter had failed to catch and hold this material although the oil was required to pass through several thicknesses of cloth stretched over the surface of a gauze strainer.

The foregoing is the only difficulty which has been encountered in the operation of either engine to date. The plant has now been in constant service, twenty-four hours a day, since September, 1922. The engines are running alternately and are kept in operation until the valves need regrinding, which is required at intervals of from six to eight weeks. When shut down, it takes from one to two days to regrind the valves and to make such slight adjustments as are necessary. This is the only time there is sufficient work about the plant to keep more than one man busy.

One of the two engines was recently given a thorough inspection. It has been in service approximately 300 days, or a total of 7200 hours. Very litle wear of moving parts was found. All bearings were in excellent shape and a surprisingly small amount of carbon was found in the cylinders.

In view of the preceding, the experience gained in the operation of Diesel engines at this particular plant would indicate the following:

1. The reliability of Diesel engines is sufficiently well established to justify their use as prime movers for pumping stations of moderate size.

2. They can be operated, if necessary, by untrained men, although this is not advised. One man, at least, should be an experienced Diesel engine operator.

3. They are sensitive to sudden changes in load. This characteristic may become the source of a great deal of trouble and annoyance if provision is not made to avoid it.

4. Expected high maintenance costs have failed thus far to materialize since nothing to date has been spent for repairs. The indications are that the useful life of the engines will be between fifteen and twenty years and that annual maintenance will not exceed 2 per cent.

5. Every precaution should be taken to eliminate all foreign matter from the fuel oil before entering the engine. This should be accomplished, first, by thoroughly pickling and cleaning the fuel supply piping before the engine is placed in operation; and second, by the use of a number of fine strainers covered with Scotch muslin, Turkish toweling or other similar fabric.

6. Attention should be given to the quality of both fuel and lubricating oil. Individual shipments of fuel oil will vary considerably in chemical composition, suspended matter and total residue. It is best to sample and test each consignment. Only a high grade lubricating oil and one recommended by the engine manufacturer should be used A poor oil, or one not adapted to the particular type of engine, will cause trouble through excessive wear and carbonization.

The engines were purchased under a guaranteed consumption of 0.48 pounds per brake-horse-power-hour, with fuel oil of not less than 18,500 B.t.u. per pound. This is equivalent to 0.065 gallons per b.h.p.-hr. The actual amount used has been slightly under this, or 0.0624 gallon. This has been probably due to the use of a better grade of oil than that specified.

Consumption of lubricating oil was guaranteed not to exceed 0.6 of a gallon per 1000 rated horse-power-hours, with engine operating at not less than three-quarters load. Up to the present time the engines have been operating at 60 per cent of full load and the consumption of lubricating oil has averaged 0.66 gallon. Fuel oil

delivered at the plant costs 5.3 cents per gallon. In 1923 the lubricating oil used cost 65 cents per gallon. The cost of power for fuel and lubricating oil has, therefore, been 3.74 mills per brake-horse-power-hour, or 5.6 mills per kilowatt hour.

TABLE 1

Annual cost of capital and depreciation

ITEM NUMBER	STRUCTURES AND EQUIPMENT	COST NEW	USEFUL LIFE IN YEARS	ANNUAL DEPRECIATION CHARGES COMPOUNDED AT 4 PER CENT
1	Building and foundations	$32,000	40	$ 336.64
2	Motor pumps and other equipment	22,000	15	1,098.68
3	Engines and generators	43,500	15	2,172.39
4	Station piping	11,000	40	115.72
5	Oil storage tanks	2,000	15	99.88
	Totals	$110,500		$3,823.31

(*a*). Cost of capital invested in plant with interest at 5 per cent—
$110,500 @ 5 per cent $5,525.00
(*b*). Annual cost of depreciation compounded at 4 per cent 3,823.00

Total fixed charges $9,348.00

TABLE 2

Annual operating costs, 1923

ITEM	KIND OF EXPENSE	ANNUAL COST
1	Labor and salaries	$ 9,900.00
2	Fuel oil, 68,255 gallons @ 5.3 cents	3,617.52
3	Lubricating oil, 730 gallons @ 65 cents	474.50
4	Coal for heating	225.00
5	Maintenance and repairs	254.00
6	Supplies and miscellaneous expenses	141.00
	Total operating costs	$14,612.02

During the year of 1923 731,000,000 gallons of water were pumped, or an average daily pumpage of 2,000,900. This is about one-half the capacity of the plant. All of the water was pumped twice; first, by the low-lift pumps under a head of 40 feet, and, second; by the high-lift pumps at 106 feet. This fact should be borne in mind when comparing the cost with other stations pumping under but one head.

In the tables, the cost per 1000 gallons of water pumped and delivered to the city mains is calculated with all fixed and operating charges included. The cost of constructing the station was $110,500. Annual interest at 5 per cent on capital invested, therefore, amounts to $5525. The sinking fund charge, calculated upon a

TABLE 3

Cost of water delivered to mains, 1923

Average daily pumpage	2,000,900 gallons
Total water delivered to mains in 1923	731,000,000 gallons
All water pumped twice:	
a. Total low lift head	40 feet
b. Total high lift head	106 feet
Total cost:	
a. Fixed charges, table 1	$9,348,00
b. Operating costs, table 2	14,612.00
Total cost	$23,960.00
Cost of water delivered to mains:	
a. Fixed charge cost per 1000 gallons	$.0128
b. Operating cost per 1000 gallons	.0200
Total cost per 1000 gallons	$.0328

TABLE 4

ITEM	KIND OF EXPENSE	ANNUAL COST
1	Labor and salaries	$9,900.00
2	Fuel oil 102,382 gallons @ 06 cents	6,142.92
3	Lubricating oil 1095 gallons @ 65 cents	711.75
4	Coal for heating	225.00
5	Maintenance and repair	1,170.00
6	Supplies and miscellaneous	211.50
	Total operating cost	$18.361.17

Estimated cost of pumping	3,000,000 gallons daily
Total water pumped per year	1,095,000,000 gallons
All water pumped twice:	
a. Total low lift head	40 feet
b. Total high lift head	106 feet

basis of 4 per cent interest compounded annually, with useful life assigned to engines and other equipment of but fifteen years, amounts to $3823. The total annual fixed charge is, therefore, the sum of the interest and sinking fund, or $9348. The operating cost for 1923

was $14,612 and was made up by $9900 for labor and salaries; $3617 for fuel oil; $474 for lubricating oil and the balance for heating, repairs, supplies and miscellaneous expenses. The sum of the fixed charges and operating costs for the year amounted to a total of $23,960. On the foregoing basis, the fixed charge cost per 1000 gallons of water is $0.128, while the operating cost amounts to $.020, making a total of 3.25 cents per thousand gallons of water pumped.

The above figures are based upon pumping at one-half capacity; to the operating cost of which must be added the total fixed charge. If the station was operated at the rate of 3,000,000 gallons per day, or three-quarters of full capacity, the fixed charges and labor costs

TABLE 5

Cost of water delivered to mains

Total cost:	
a. Fixed charges, table 1	$ 9,348.00
b. Operating cost, table 4	18,361.00
Total cost	$27,709.00
Cost of water delivered to mains:	
a. Fixed charge cost per 1000 gallons	$.00854
b. Operating cost per 1000 gallons	.01677
Total cost per 1000 gallons	$.02531

would remain the same. The only change would be for additional fuel and lubricating oil, plus a proportionate increase in the cost of repairs and supplies. Although no such expenditure has yet been made, a charge of 2 per cent of the engine cost should also be included for their maintenance. With these items of additional expense allowed for, the cost of the two pumpings at the rate of 3,000,000 gallons per day should not exceed the sum of $.025 per thousand gallons of water delivered to the city mains.

DISCUSSION

Mr. C. M. Everett:[3] The value of the Diesel engine as a means of driving pumps has not been sufficiently realized, but there are indications that this type of prime mover will become better known. There is already considerable interest being displayed by waterworks men, due probably to the increase in the cost of coal and of labor.

[3] Of Hazen and Whipple, New York, N. Y.

Diesel engines do not require much of an operating force, and at present average prices of coal the cost of oil for running a Diesel engine driven pump is less than the cost of coal for running anything but the largest and most efficient steam pumps.

The City of New Britain, Connecticut, has a Diesel engine driven pump in their White Bridge Pumping Station. This station was designed in this office and constructed in 1922 and 1923. The White Bridge Supply at New Britain is an emergency well supply intended to help out the main supply from impounding reservoirs in dry years. It consists of a line of twenty tube wells in a sand deposit about 40 to 50 feet deep, a concrete suction well about 50 feet in diameter with no bottom, and a pumping station with a single Diesel engine driven pump.

The wells are all connected to a cast iron header which discharges into the suction well through a vertical pipe extending down to a point near the bottom. The pump takes its suction from the opposite side of the well.

The water is thus siphoned out of the tube wells as the pump does not pull directly on the wells. As air collects at the top of the siphon it is removed by a vacuum pump. The main purpose of this arrangement is to keep the sand out of the pump suction, using the suction well as a settling basin for which purpose it has proved itself very efficient.

The suction well is also used as a means of getting water out of the sand. It is estimated that the yield of this concrete suction well amounts to about $1\frac{1}{4}$ million gallons per twenty-four hours.

The pump is a horizontal duplex plunger pump geared to a two-cylinder, two cycle, vertical, solid injection, full Diesel oil engine.

The pump has a capacity of 3 million gallons per twenty-four hours against a total head of 250 feet. The engine is 150 b.h.p. and runs at 275 revolutions per minute.

Various types of pumps and methods of driving them by the oil engine were considered for this installation. The type used was selected for the following reasons:

1. The plunger type of pump would operate under a high suction lift.

2. With nothing between the oil engine shaft and the pump shaft but a single gear, the overall efficiency is high.

3. The first cost is not high, considering the reliability of the type of drive and the high efficiency attained. A belt driven centrifugal unit would be cheaper and its efficiency would be good, but a belt was considered an undesirable feature in the plant at least for the main drive.

4. The unit is flexible. It will run smoothly at a capacity of 1.85 million gallons per day, and under this condition which represents half load on the engine, the overall efficiency of the engine and pump expressed as a duty of foot pounds of work done per pound of oil burned, was 83 per cent of the duty at full load.

This equipment has given good service since it was tested in June of last year. It is not run continuously, but is used only during the summer months. For this reason no duplicate was installed or considered necessary.

The total cost of the White Bridge supply was about $170,000. The well system with the suction well cost about $70,000, the pumping station with all equipment complete, about $60,000, and the remaining $40,000 was spent on the pressure main, the land, roads, etc.

The cost of operation is low. One man on a shift easily takes care of the whole outfit. One man of the operating force was trained in the factory where the Diesel engine was made and this is believed to be always desirable in operating a Diesel engine. It is not a vital requirement by any means, but it will save time and expense when troubles occur.

Oil is delivered at the station by oil trucks of the oil company. It cost 1 cent per pound in the tanks last summer. With oil at 1 cent per pound the cost of operation of the station, including labor is about $14.00 per million gallons of water pumped or about 5.6 cents per million gallons per foot. The fixed charges amount to about $4800 per year. On the basis of 120 days use of the source per year, this will amount to about 5.3 cents per million gallons per foot. This figure would be lower, of course, if the station were used more.

The total cost of water delivered to the mains is in the neighborhood of $.027 per thousand gallons, considering pumping station alone, and about $.05 per thousand gallons for the whole supply, for the whole cost including fixed charges.

CURRENT PRACTICE IN THAWING FROZEN SERVICES AND HYDRANTS

By F. A. McInnes[1] and J. M. Goodell[2]

Some water works have more trouble from frozen services and hydrants than have others in about the same latitude. This is due to differences in climate, soil and the protection against deep frost given by snow on the ground. There can be, therefore, no universally standard practice in thawing such services and hydrants. Each water works must adopt those methods of thawing which best meet the conditions due to freezing in the past. No practicable preventive measures to diminish the trouble have been found yet, while the experience of the winter of 1917–1918 indicates that the prompt removal of snow from street pavements and sidewalks may possibly increase somewhat the tendency for freezing to occur.

Where only a few service pipes are frozen during the average winter the customary method of thawing them is with hot water or low pressure steam, furnished by a small portable boiler which can be carried by two men into the basement of the building with the frozen service. These boilers are generally provided with kerosene burners. The service pipe is disconnected between the meter and shut-off valve, if the latter is of such a pattern that a small pipe to carry the steam or hot water can be passed through it when open.

In some cases it is necessary to take off the shut-off valve in order to insert the small pipe. When this is done, it may be desirable, in order to avoid unnecessary flooding of the basement floor, to shut the curb cock, thaw the service to that cock, and then open it just enough to see if the water will flow. If the ice has all been thawed so the service is clear, the curb cock can be closed while the pipe connections are made up again in the basement, and there will thus be no trouble with water pouring over the basement floor. If the service is found to be frozen between the curb cock and the main, then the curb cock must be opened and the small steam or hot water pipe pushed through the cock until the whole service is thawed.

[1] Consulting Engineer, Boston, Mass.
[2] Civil Engineer, Upper Montclair, N. J.

Where steam is used, generally under 3 or 4 pounds pressure, the steam outlet of the boiler is connected to a $\frac{3}{8}$-inch lead or $\frac{3}{16}$-inch block tin pipe which is slowly forced into the service at the point of disconnection in the basement. As soon as it is stopped by the ice, steam is turned on and as the ice melts the pipe is moved ahead gently. The steam condenses and flows back into the basement, where provision for catching it must be made in order to avoid flooding the floor.

Where hot water is used it is generally pumped from the boiler into the small thawing pipe by a hand force pump. The backflow of water from the service must be saved for boiler feed; if buildings are far apart considerable time may be lost in obtaining water to feed the boiler if the backflow is not saved, because much more water is needed for thawing by the hot water method than by the steam method.

The advantages of thawing by steam or hot water are that the apparatus is inexpensive, can be used by the water works employees without electrical training, and can be employed wherever boiler feed water is available. The disadvantages are slowness in thawing, compared with electrical methods, and the difficulty sometimes encountered in passing the small thawing pipe through the openings in cocks and valves. The method will probably continue to be used exclusively by those water works having only a few services frozen annually, except in those rare winters like that of 1917–1918, when the help of the local electric lighting utility can be enlisted in meeting such an unusual emergency, as explained later.

Where the annual number of frozen services is large, except in unusually open winters, the present tendency is toward the water department owning an electric thawing outfit. This generally consists of a gasoline engine mounted on skids with a dynamo driven by it. About 55 volts is desirable and the set should be able to deliver 15 to 35 kilowatts. There is usually a switchboard with cut-out switch, rheostat, voltmeter and ammeter. Sometimes the rheostat is merely a keg containing brine, with a metal plate on the bottom and another which can be raised or lowered so as to vary the depth of brine between the plates and consequently the resistance to the flow of the electric current from one plate to the other. This is called a water rheostat. The current passes from the dynamo to the rheostat, then through a covered cable, usually of No. 4–0 size, to a clamp on the frozen service pipe inside the building. The service pipe should

always be disconnected at the meter to prevent any possibility that the current used in thawing may flow into the plumbing system of the building. Neglect of this precaution has caused considerable trouble. The other side of the dynamo is connected to a hydrant by another cable. As a rule a current of 175 to 225 amperes and 15 to 20 volts is all that is necessary to thaw the average small service, but cases may arise with larger pipes where more current and somewhat higher voltages can be used safely. Great care must be taken in all electrical thawing that an unduly large current is not used in an effort to hurry up the work. While an overheated pipe line may not fail when it is put in use again, it is liable to do so later. Couplings of service pipes seem to be particularly subject to injury by heavy currents, probably because they offer greater resistance than does the pipe itself to the passage of electric currents and are heated higher than the pipe in consequence.

After the connections are made the actual thawing takes only 6 to 12 minutes with most small services. These outfits afford the quickest relief from frozen services which water departments can obtain and they can be used wherever a truck can go. They are relatively expensive, however, even when built of second-hand apparatus.

In some cities owning electric street sweeping machines, the storage batteries used on these machines have been taken out for emergency thawing work as a substitute for the engine-dynamo set just mentioned. The best method of connecting up the cells of such batteries depends upon the number and type of cells and the current desired. With storage battery outfits the water works superintendent should make very sure that the connections will not permit an excessive current to be delivered. A rheostat and ammeter should be provided and the outfit should be operated by a man who can be relied upon to use only suitable current. With these outfits 16 volts are enough for the average small service pipe. Where it is certain such batteries will be available for emergency use, the method of connecting and transporting them should be worked out carefully and the switchboard and cables provided before the need for them arises. It will be necessary, of course, for the water works superintendent to make sure that the cells are kept fully charged and ready for use during the period when freezing may occur. A battery must be recharged after a continuous day's use, the operation taking approximately eight hours time.

An outfit using an engine-dynamo set or storage battery, capable of being transported on a truck or sledge, is free from the limitations of electric thawing equipment deriving current from electric lighting circuits, which are not always within reach of the localities where thawing must be done. Nevertheless, the use of current from such circuits is a valuable emergency measure for which it is well to be prepared. The method consists in making temporary connections to the lighting circuits with cables which are run to transformers. These reduce the voltage to that required for thawing. The transformers are usually connected through a rheostat, ammeter, voltmeter and switches to cables which are attached to the frozen service and a hydrant, as already described. Sometimes the rheostat is omitted when it is known that the apparatus will be handled by careful, competent electricians who understand how to change the resistance of the cables by looping them; in such cases cables of No. 0 size are employed. It is questionable, however, whether the omission of the rheostat should be permitted on account of the danger of excessive currents flowing into the service through some oversight.

Some years ago several makers of transformers manufactured special pipe-thawing transformers, but the sale of them was so small that they are no longer made. One manufacturer states that they now usually recommend two 25 or $37\frac{1}{2}$ kva. transformers with a low voltage of 110 volts and a high voltage conforming to that of the local electric lighting system. For example, they recommend that two 2300-volt transformers be connected in series on a 2300-volt line and the 110-volt windings be connected in parallel with each other, thus giving about 55 volts on the cables to be attached to the service and hydrant. For a main 6 inches or more in diameter, both the primaries and secondaries can be connected in parallel, giving 110 volts.

Distribution transformers suitable for this work are usually kept in stock by electric lighting utilities, so there is rarely any reason for a water department to buy them. Inasmuch as the connections with lighting circuits should be made only by employees of the electric utility, such an electrician should be a member of each gang using one of these transformer outfits. Present practice is for the water department to hire the equipment and electricians from the lighting utility as needed and add a water works foreman and laborers. Where such an outfit is used the electricians should be carefully instructed regarding the danger of using heavy currents.

When such equipment is connected to the lighting circuit and the frozen service, it will thaw the pipe just as quickly as a self-contained outfit will do the work. Its drawbacks are the time needed to make the connections with the lighting circuits in some cases and the occasional impracticability of making any connection at all. It is so effective, however, when properly used, that wherever emergency equipment is likely to be useful, it is advantageous to have it in readiness by mutual arrangement between the water and electric lighting officials, before severe cold weather arrives.

Thawing hydrants and their branches, like thawing large mains, requires equipment of greater capacity than is needed for thawing service pipes. When the work is done by steam, an upright boiler is generally used; sometimes an old fire engine is available for the purpose. The steam is delivered through a hose into one of the nozzles of the hydrant. If the branch is frozen, it is usually necessary to remove the hydrant and insert the steam hose into the end of the branch. Where a hydrant branch has once been frozen, the hydrant pot and branch should be lowered if this is possible. If the trouble is in the barrel, above the bottom valve, denatured alcohol or some other anti-freezing substance should be placed in the barrel.

When the hydrant and its branch are thawed electrically the currents are so heavy that only a thoroughly competent, careful electrician should be in charge of the electrical part of the work. In fact, wherever electrical thawing is practiced, care must be taken to prevent any annoyance to the public by straying currents, and the danger of causing a fire hazard or of damaging pipes, particularly pipe joints, by excessive currents must never be overlooked.

SOFTENING OF PUBLIC WATER SUPPLIES[1]

By Gale S. Strout[2]

It has been said that "It is almost an axiom that a good water supply is essential to the prosperity of a municipality." Such a statement made ten years ago would necessarily call for more limitations than a similar utterance today. The advancement made in the methods of rectification of waters for human consumption and general use in recent years would remove the necessity of limiting a general statement as above, and today it can be truthfully stated that it is a recognized axiom that good water is essential to the prosperity of a city and one of the prerequisites of a water supply. Until now, a good water supply has meant, in the majority of instances, an abundance of water, one free from turbidity and from disease-bearing germs. It should also be free from obnoxious odors and pleasant to the taste. A water with these qualifications was unquestionable. It is only natural that the question of sanitation was paramount and the first endeavors of the water companies were those looking toward the potability of the supply.

But civilization does not stand still. It either advances or goes backward and the public demands become more and more exacting. What may have been sufficient yesterday may fall far short of supplying the needs of today. If the proper steps have been taken to safeguard the consumer's health, the next step to be taken will be an economic one and his financial welfare must be attended to. Whether or not the water companies in rendering public service will voluntarily take the initiative and furnish a water free from hardening salts as well as one free from disease-bearing germs is problematic. I think that it can be truthfully stated that in America up until now, not a single water softening system has been put into operation for a municipal supply where the original supply was clear and clean and otherwise fit for human consumption, although the water itself was very hard. There have been a considerable number of cities, using

[1] Presented before the California Section meeting, October 26, 1923.

[2] District Manager, Water Softening Division, Wayne Tank and Pump Company, San Francisco, Cal.

the turbid waters of the rivers of the middle western states, which have resorted to purification, principally filtration, and as a by-product of filtration, have partially softened the water. There are others that have built fairly extensive water softening plants in conjunction with the filters and operated them extensively with gratifying results. Nevertheless the real pioneer among municipalities to actually soften a clear, clean and otherwise satisfactory but hard water is yet to be proclaimed.

Although the terms "hard" and "soft" waters are ones that we have all heard since our earliest recollections, they are only relative and the interpretation put upon them varies with the individual and the section of the country from which he comes. If a resident of Portland or Seattle were to speak of hard water, he would probably mean anything from 2 grains per gallon up, while some one from Coalinga mentioning soft water would probably mean anything below 30 grains. Nothing is large or small, tall or short, except by comparison. To a child, a man below the average height would appear tall. And so it is with waters. They are either hard or soft according to our established unit of comparison, and our established unit of comparison is undoubtedly that water with which we are most familiar. A citizen of Fresno is perfectly safe in boasting of his wonderful soft water supply to a man from Los Angeles or San Francisco, but he should be more reserved in his statements to his friends from Portland, Seattle or Long Beach. In order that I may show definite comparisons of waters of different degrees of hardness, I have here labeled samples of waters in bottles. These samples are,

1. Distilled water
2. Fresno City water
3. San Francisco Spring Valley Water
4. A San Francisco well water

In this case the distilled water is logically the basis of comparison because it is pure and therefore free from all salts as well as the hardening salts. It has (1) unit of soap, Fresno City water 9 units, San Francisco Spring Valley 11 units and the San Francisco well water 35 units. In each case, soap has been added until the corresponding suds rise to the same height and become permanent.

In the addition of soap to these waters they have been softened. The proof that they are now soft is in the fact that the suds remain fixed. The suds will disappear unless all the hardening salts are destroyed. If we were to take one thousand gallons of water from

each of the three supplies from Fresno, San Francisco and the San Francisco well water, the cost of softening with pure soap, soap costing 10 cents per pound, would be respectively \$1.20, \$1.50, \$5.10. To actually soften the water by a removal of the hardening salts by present day methods would be \$.02, \$.026, or \$.085, cents per thousand gallons respectively or one-sixtieth as much as by using soap and many times more satisfactory.

When a utility, whether privately owned, mutual or municipal in nature, takes up anything that is new or in any way savors of an innovation it must do so from a somewhat different angle of approach than that of an owner of an industrial plant. An individual has no one to whom he must answer or give an accounting. He makes his own investigation in his own way and if his findings lead him to believe that the investment of funds for any particular purpose will assist him in his business, he makes the necessary expenditures and takes the consequences. If his study was wisely made, he will either simplify the methods of production, reduce labor cost or produce a finer grade of finished product according to what the particular object of the investment was. He is at least the winner or loser. But with the public utility, it is not so simple. Every utility corporation has as many critics as it has consumers and it must answer to them in some way, through city councils, utility commissions or some other rate fixing board. Take the problem of supplying a soft water. There are very few cities so favorably situated that a natural soft water supply is available. Under these conditions there is only one alternative and that is actually to soften the existing supply. To do this requires additional capital investment and additional operating expense. This additional cost for water must be borne by the consumer and the additional rate to the utility must be granted by the rate fixing board. The utility corporation must therefore educate the consumers to the value of soft water in advance if it is to take the lead in its special line of service. This educational work is necessary because the general public does not understand the value of soft water. Very few people have ever experienced soft water in the home and have therefore no real unit of measurement by which to determine the value. They are, in the masses, unconscious of the load they are carrying in their daily battles with sticky curds, clogged pipes and heating systems that will not heat. To these troubles they have become to a large extent immune because they are considered unavoidable and they have unconsciously resigned themselves

to the conditions. Such conditions are unnecessary but exist in most city supplies. In this day when every man is a specialist, it is only fair to consider that the utility corporation is a highly organized specialist always alert to give the best possible service within its power for which the public will pay. By its specialization in service it should give to the public the service in advance of public demands. It should always be just ahead of public demands and never behind. It must be the educator and teach its consumers the value of the service to be rendered so that if an additional rate must be obtained it will be understood and granted.

In the case of soft water the consumers would of necessity have to pay more per thousand gallons for the water, but they in turn would be financially benefited because of savings made in other ways. Consider for instance the benefits to be derived in the average home. To soften water with soap requires per thousand gallons of water $1\frac{1}{4}$ pounds of soap per grain of hardness, or on a water like that furnished by the Spring Valley Water Company, 15 pounds of soap, which at a cost of 10 cents per pound would be $1.50. If the water were softened before delivery it would entail an extra cost to the consumer of probably five cents per thousand gallons. This would mean that if one-thirtieth of the water used in the home were used with soap then the consumer living in San Francisco could afford to pay five cents more per 1000 gallons for his water without increasing his monthly expenditures. The benefit that he would derive, however, from saving in soap would be the smallest of the benefits that would accrue from the advantages thus obtained. In the home, first of all, would come the real luxury of the use of soft water. This would appear in the reduced labor of house work, for with soft water a sticky curd or high water mark on the bath-tub is unknown. The same is true of the wash basin or the kitchen dishpan. Clothes washed in soft water have an increased life of from twenty-five to one hundred per cent. Not long ago I learned of two laundries that ran tests of the life of collars washed in hard and soft water. In the laundry using soft water, the collars lasted nearly twice as long as they did in the one using hard water. Then too there are the advantages of reduced cost in plumbing. With soft water no scale is deposited in hot water pipes. This means long life to waterbacks and copper coils in heaters, fewer plumbing bills as well as reduced cost in fuel consumption due to better heating conditions. It would appear therefore that the advantages accruing to the home in reduced

costs are many times that of the saving in soap and many times that of the additional cost of the soft water.

In industrial lines the savings are equally as large as in the home and much more readily measured. Take for example a hotel. A hotel of 500 rooms has a linen bill annually of $30,000.00. Soft water versus hard water will increase the life of linens at least one-third, a very tangible asset for the hotel company. A similar advantage is obtained in the operation of boilers, for without scale but little cleaning is required, and fuel consumption correspondingly reduced. It is not improbable that of all the fuel burned in San Francisco today for heating purposes and the generating of steam five per cent could be saved if the water used were free from scale forming salts. The hardening salts in water and scale forming salts are synonymous. In San Francisco each month there is burned approximately 240,000 barrels of fuel oil. If oil is worth $1.20 per barrel and 5 per cent could be saved, then there would be an annual saving of about one quarter of a million dollars on fuel alone. Add to this the reduced cost of boiler cleaning and the increased life of boiler tubes and boilers and you will obtain an amount great enough to pay for the cost of softening all the water of the city for a year. In one small boiler plant in San Francisco carrying an average load of 400 horsepower the owner reduced his operating costs about $3000.00 annually by a change from hard to soft water. This amount was made up almost entirely from saving in boiler cleaning. The saving in oil was largely intangible due to the nature of the load carried and the lack of records. In Oakland an industrial plant wiped out a ten thousand dollar investment in six months of operation due to increased production and better quality goods made possible by soft water. Another company in San Francisco was threatened by their insurance brokers with entire shut down on account of a badly scaled boiler and they had no standby boiler to alternate to during repairs. A soft water plant was installed, the scale removed by dissolving of scale in the soft water and the threatened shut down avoided. These are scattering examples only, but it takes but little imagination to picture the industrial advantage one city with soft water would have as compared to another equally well located but supplied with a hard water.

The beneficial results that would be obtained by softening a city water supply would vary according to the nature of the city, whether industrial or residential. The degree of hardness of the raw water would have little to do with the installation of the system when con-

sidered from an economical standpoint, considered in terms of an investment because hardness in water is detrimental and obnoxious in proportion to the amount present. If hardness in water is a disadvantage then its absence is equally an advantage. If hardness is present in the water supply then the benefits derived by its removal are in direct proportion to the amount removed. If it is an advantage to eradicate five grains of hardness in a water supply carrying ten grains, then it is twice as advantageous to eradicate ten grains. In other words if there is hardness in the water supply and it is worth while eliminating any part of it, it is equally and proportionately advantageous and worthwhile to eliminate it all.

The process of softening should be that method best adapted for removing all the hardness from the water with the least expense. No arbitrary rule can be laid down that will fit all conditions. Each case is a special problem and must be so treated.

Although municipal supplies have not been softened here in the West, the individual industries in many instances have not overlooked the opportunities and advantages to be derived by softening their own supplies. As an example of this I will cite the city of San Francisco where the total average daily water consumption is about 46,000,000 gallons. Of this amount 8,000,000 gallons is pumped from wells and 38,000,000 gallons supplied by the Spring Valley Water Company. There are privately owned water softeners in operation today softening 8 per cent of the total amount of water used in San Francisco, having a combined softening capacity capable of softening fifteen per cent of the total amount of water delivered by the Spring Valley Water Company and the rate at which the softeners are being installed is continually increasing. They are being installed for all lines of industries and there are today thousands installed in private homes in the State of California. As rapidly as the public really learns of the possibilities and advantages of water softening installation, they are being installed. What is true of the city of San Francisco in respect to the per cent of consumed water being softened is more or less true of every city in the State having a population of 10,000 or over.

The cost of the privately owned water softeners in the City of San Francisco today is greater than would be the cost of a centralized station installed and operated by the Water Company to soften every drop of water delivered by that Company through its mains. It is interesting to note here the extent to which an individual will go to

obtain soft water for his home. The initial cost of installation of a household softener is 150 times as great as it would be to obtain the same amount of capacity through a large centralized station. You will realize what this means when you recall that of the water sold through your systems over half is for household and commercial uses other than direct industrial and municipal consumption.

A public utility corporation, being monopolistic in nature, has a duty to serve. It is its duty to serve to the utmost and give the maximum of beneficial service for which the public will pay. If, by removing the hardening salts from the water delivered to the consumers, it is thereby rendering a service, the value of which is greater than the additional necessary charge for the service rendered, then the water should be softened. In view of the rapid advancement that has been made in methods of water softening in very recent years, the present cost of softening water and the enormous resultant savings effected in all lines of industry and in the home by the use of soft water, it is not improbable that the time has arrived when every water company should seriously and actively take up the question of softening its supply. It should anticipate the needs of its consumers and give that service which by its position can be done on a wholesale basis so much better and cheaper than the same results can be obtained individually. This applies to all companies that are not now serving absolute soft water. Remember that a hard water is objectionable in porportion to the hardening salts present. Likewise the benefit derived from softening the supply is in proportion to the hardness removed. The initial cost of the softener is nearly proportional to the amount of hardening salts to be removed and the actual cost of softening the water is directly proportional. Under these conditions, it is easily forseen that water companies in the future will soften as well as purify municipal supplies with benefits to both the public and themselves.

COMPOSITION OF ALUM FLOC IN MIXING BASIN

By Edward S. Hopkins[1]

Last year Miller (1) published a study of the composition of floc from alum solutions. This paper presented certain fundamental facts of importance to the study of mixing basin floc. Showing the applicability of these principles to plant operation will be the object of this paper.

Baylis (2) found when using Gunpowder River water that a liter sample required fifteen minutes stirring at 100 revolutions per minute with mechanical agitator, after addition of the coagulant, to produce a floc which duplicated that obtained from the effluent of the plant mixing basin. Therefore, floc obtained from agitation in this manner can be considered equivalent to that produced under plant conditions.

This study covers pH values from 4.0 to 9.8 and alum concentrations of 1, 5, 10, 25 and 50 grains per gallon.

METHOD OF TEST

Samples of river water (turbidity not exceeding 15 parts per million) were treated with a given dose of alum in liter beakers, rapidly mixed by stirring with a rod and then agitated with mechanical stirrer as noted. pH value was determined upon completion of agitation and sample allowed to settle for thirty minutes. The precipitate was washed by centrifuging and subsequent decantation with hot water until free of sulfates, care being taken to break up the floc at each washing.

When necessary, either sulfuric acid or sodium hydroxide was added to the water to produce a given pH value.

Determinations were usually made for every 0.5 pH value.

RESULTS.

It was not possible to produce good floc below pH 4.5 (for 1 grain per gallon alum—pH. 5.2).

[1] Sanitary Chemist, Water Department, Baltimore, Md.

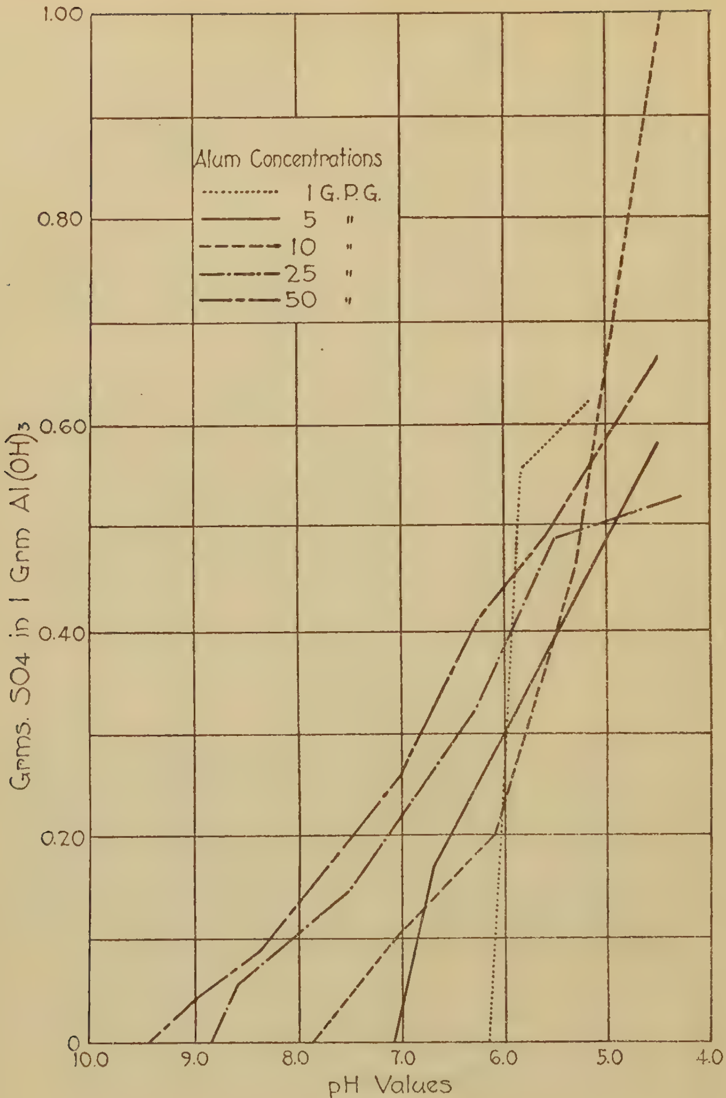


Fig. 1

Figure 1 presents the amount of sulfate found in floc at varying pH values with a given alum dosage. It is clearly shown that as the pH value decreases the amount of sulfate present increases. Deter-

mining the pH value of a settled water and referring to the curve will show whether sulfates are present or absent in the floc.

Assuming pH 6.5 to exist in the average mixing basin. Sulfates are absent using 1 grain per gallon alum, but increase in small quanity with greater concentrations.

Miller plotted his sulfate values in the mol ratio of $\frac{Al}{SO_4}$. This gives a number which increases as the sulfate content decreases. Figure 2 expresses results in a similar fashion. The ratio of Al to SO_4 is almost constant between pH 4 5 and 5.5 and at higher pH

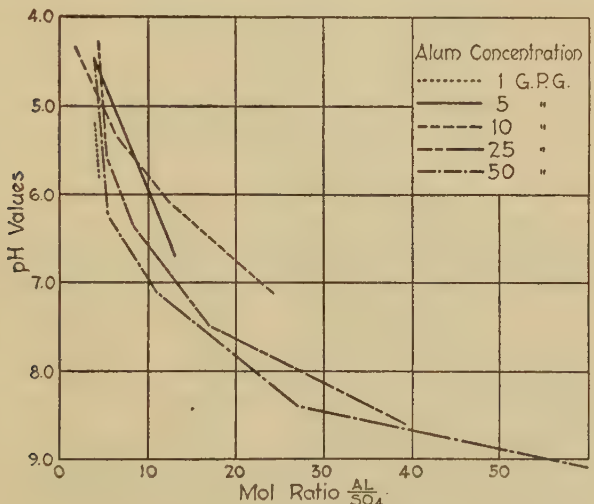


FIG. 2

values rapidly becomes greater and eventually increases to infinity, which compares very favorably with Miller's curve. It is noted that the sulfate decreases more rapidly in the dilute solutions and disappears at a lower pH value.

Plotting the mol ratio of $\frac{Al}{SO_4}$ against the mols of NaOH per mol of Al added to produce the floc (fig. 3), it is found that the points are reasonably correlated. In computing the amount of alkali added the alkalinity of the water was calculated to NaOH thus giving equal value for all alkali present.

It is shown that, when less than three mols of Na OH are added per mol of Al, the precipitate remains practically constant in com-

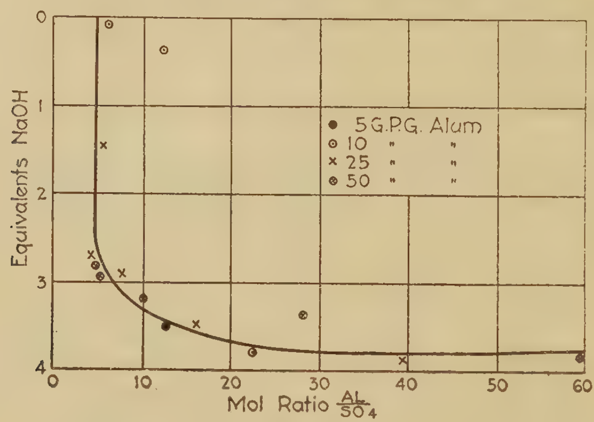


FIG. 3

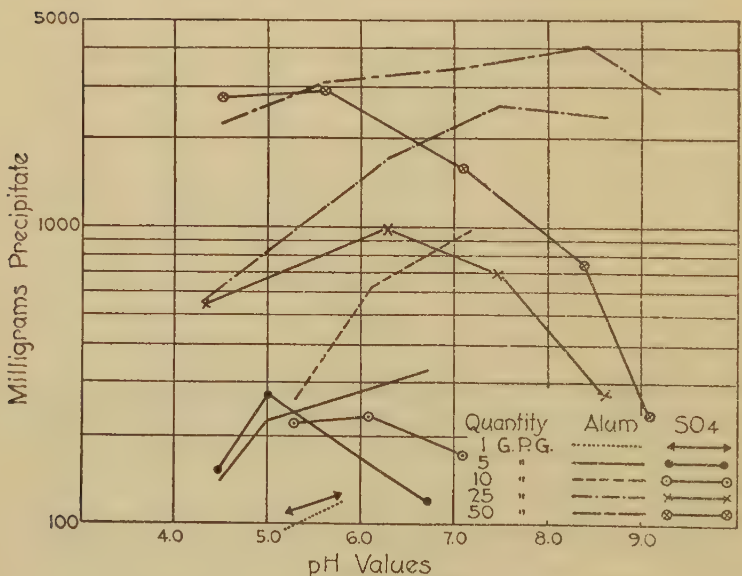


FIG. 4

position and approximates the formula $5(Al_2O_3)\ 3SO_3$ as stated by Williamson (3) to exist. The applicability of this formula to the

floc was proved by actual determinations, pH values from 4.5 to 6.0, at all concentrations of alum, giving results in absolute agreement.

Upon addition of more than 3 mols of alkali the proportion of sulfate decreases and it is finally possible to wash the precipitate free of it. In general agreement with Miller this would indicate for dilute solutions, that when a quantity of sodium hydroxide in *excess* of that required to react with the aluminum ion according to the equation $Al \div 3\ OH = Al(OH)_3$ is present, the precipitate can be washed free of sulfate.

It is not possible to advance the hypothesis that sulfate absorption is due to mechanical attraction by the precipitate. If this were true, the quantity of sulfate present would increase with corresponding increase of precipitate. Curves shown in figure 4 prove this hypothesis unfounded, for as the quantity of floc at a given alum concentration increases the amount of sulfate decreases, equal volumes of the same solution being used for the analysis.

This study has been presented to prove that floc precipitated from the dilute solutions necessary in water purification processes and under stimulated plant conditions has the same chemical composition as stated by Miller (1) to be true for that precipitated from concentrated solutions.

REFERENCES

(1) Miller, Lewis B.: On the composition of the precipitate from partially alkalinized alum solutions. Pub. Health Reports, **38**: 35, August 31, 1923.

(2) Baylis, John R.: The use of acids with alum in water purification and the importance of hydrogen ion concentration. This Journal, **10**: 3, May, 1923.

(3) Williamson, F. S.: Basic aluminium sulfate. Jour. Phys. Chem., **27**: 284, 1923.

DISCUSSION OF REPORT OF COMMITTEE NO. 6 ON INDUSTRIAL WASTES IN RELATION TO WATER SUPPLY[1]

Mr. W. L. Stevenson: The Sanitary Water Board of the Commonwealth of Pennsylvania, referred to in the excellent report of Committee No. 6, organized for the transaction of official business on July 17, 1923, and has to date held twenty-one meetings, approximately twice a month. The problem of utilization and conservation of the natural water resources of the State of Pennsylvania confronting the Board is stupendous.

A large proportion of the citizens of the State dwell in incorporated municipalities provided with public sewer systems. Pennsylvania is one of the greatest industrial States in the Union. The development of natural resources such as coal and oil and the many kinds of industry all constitute actual or potential sources of stream pollutions. It is, therefore, apparent that the major problem demanding a solution is the conservation of the streams as sources of public water supply, for fishing and recreational use and also the utilization of the streams for inoffensive and harmless disposal of polluting materials by dilution.

The fundamental resolution of the Board for classifying streams is the proposed solution of this problem. Fish wardens of the Board of Fish Commissioners, Forest Rangers of the Department of Forests and Waters and Health Officers of the Department of Health in the performance of their normal field duties are traversing the now unpolluted tributary streams and certifying on maps prepared for that purpose those streams which they find to be unpolluted from any artificial source. This work is being chiefly done in the northern and southern tiers of counties and in the eastern part of the State because in those localities are to be found most of the now clean streams.

After reports are made, the Sanitary Water Board by appropriate action designates such streams as Class A. Since the meeting on

[1] Presented before the New York Convention, May 22, 1924. See Journal, May, 1924, page 628.

February 12, 1924, the Board has designated as Class A about 3500 miles of streams in Pennsylvania among the following counties: Bedford, 595 miles; Cameron, 225 miles; Franklin, 1000 miles; Fulton, 560 miles; Monroe, 700 miles; Pike, 380 miles; total 3460 miles.

Field surveys and examination of office records are under way by the engineers of the Department of Health for the purpose of making report to the Board for designation of streams draining inhabited watersheds as Class B and Class C.

Reasonably clean water is essential to processes of manufacture in many industries and there are industrial wastes causing stream pollution which may contain by-products of value. If through research, ways and means could be found to remove such constituents it would not only be a benefit to such industries, but simultaneously would cause abatement of the stream pollutions. To that end the Sanitary Water Board has already had and proposes to have further conferences with representatives of industries to attain coöperative and mutually beneficial results.

A recent opinion of the Attorney General to the Secretary of Health is of interest to waterworks managers, namely: that the Sanitary Water Board has jurisdiction over the discharge of wastes containing taste and odor producing constituents such as phenol, gas house wastes, etc., provided that such substances do or are capable of producing sufficient tastes and odors in a public water supply derived from the stream into which the wastes are discharged, that the public using such public water supply refrain from drinking a substantial quantity of water or resort to the use of apparently attractive water from private sources but which may be contaminated and thus in either case menacing the health of the public.

Mr. J. W. Ellms: The situation in Cleveland has been one of considerable interest and difficulty. A very foul taste in the water supply has been noticed for a number of years. It was doubtful for a long time as to where and what was the cause of these intermittent tastes, which came generally in the fall or winter months or with the breaking up of the ice in the lake. In 1920 we undertook an investigation to find out the source of the taste-producing substance or substances, and by a series of eliminations and the collection of some 1100 or 1200 samples, we succeeded in locating the source of the trouble. These we traced to three by-product coke oven plants. These three by-product coke oven plants are located on the Cuyahoga

River. They were discharging their wastes into the Cuyahoga River. The wastes containing phenol came from the ammonia stills, from the benzol plants, and from the coke quenching process. It was very difficult to determine where the sewage went, but, by the analytical work we did, we were able to do so. We brought these manufacturers into a conference with the Health Department officials and laid this report before them and they admitted that they were the people who were causing the trouble. We then asked them to cease doing this, and we tried to make it plain to them that the nuisance which they were creating was something that could not continue and asked them to find remedies for it. Nothing was done for a year or two. The State Health Department supported us in our plans. There were opinions of the Attorney General's pro and con as to whether it was a real health menace or not, but, finally, with some officials of more backbone than others, we succeeded in bringing these manufacturers to a sense of their duty in the matter and they have put in operation a system by which these wastes are taken out of the Cuyahoga River. One concern has spent about $300,000 in changing its plant. Two other concerns have spent over $100,000 in addition; something approaching a half a million dollars has been expended to keep these wastes out of the supply. We hope that these are the principal sources. There may be some other sources, but it is the intention of the city to conduct another survey in order to determine whether this is the case or not.

With respect to phenol wastes, it is certain, as far as we know and from the investigations we have made, that they must not be permitted to enter a water supply, for once they get into the supply there are no known processes, at least that I know of at the present time, by which we may remove phenol. If chlorine is used as a disinfectant, the combination of the two certainly produces the foulest tasting water you can imagine;.

Mr. H. R. Crohurst: In regard to the phenol waste problem the Public Health Service has been coöperating with the State Boards of Health in an endeavor to work out a satisfactory solution of the problem.

On January 29, 1924, the Surgeon General of the Public Health Service called a conference at Washington of the State health organizations to discuss the extent of the phenol problem, to obtain ideas as to the necessity of federal legislation at the present time to assist in

the elimination of this waste and to go over in general all phases of the problem.

As a result of the Washington conference it was the concensus of opinion that drastic legislation at the present time would not aid materially in the solution of the problem, that the majority of the individual states already had sufficient legislation to prevent stream contamination if recourse to the courts was necessary and that first some plan of coöperation with the manufacturers should be attempted.

Since a large majority of the by-product coke plants are located on the Ohio river watershed, an organization of the Health departments of the states on the Ohio river drainage area was formed with Dr. John E. Monger, Director of Health, Ohio, as chairman and E. S. Tisdale, Director of Sanitary Engineering, West Virginia, as secretary.

At the request of the chairman of this organization the Public Health Service gathered information as to the number and ocation of phenol waste producing plants on the Ohio river watershed and the number of water works plants that have had or now are having trouble from taste and odors due to phenol contaminated water.

Briefly, the survey showed that there were 19 phenol waste producing plants on the watershed, the majority being located in Pennsylvania, Ohio and West Virginia; that approximately 27 water works plants have reported trouble due to tastes and odors from the combination of phenol and chlorine used for disinfection and that there are 24 other communities using treated surface supplies in conjunction with chlorine that have not as yet reported trouble, but which are located below phenol waste producing plants and may at some future time be subject to these disagreeable tastes and odors.

Mr. E. S. Tisdale: The "Phenol Wastes Conference of States on the Ohio River Watershed" was held at Pittsburgh, April 14, 1924.

There were in attendance between 40 and 50 delegates. The States of Ohio, West Virginia, Pennsylvania and New York were represented by the Health Commissioners and Chief Engineers of the State Health Departments. The United States Public Health Service sent both medical and sanitary engineering personnel and several consulting engineers interested in phenol wastes disposal also attended the conference. The by-product coke industry representatives who were there by invitation numbered about forty. The purpose of meeting jointly in this manner was to gather evidence

as to the experience of the coke industry in handling phenol wastes. Also it was hoped that machinery might be set in motion for amicably solving the question of disposing of the objectionable taste-producing industrial wastes which are now damaging public water supplies and thereby injuring public health.

The United States Public Health Service, following a careful study by a well qualified sanitary engineer, presented a report showing the distribution of phenol wastes-producing plants on the Ohio River watershed and communities reporting tastes and odors in their public water supplies. The report was complete with tables and maps and showed clearly the magnitude of the problem. This was presented at the start of the conference.

The chairman of the conference, Dr. J. E. Monger, Director of Health, Ohio State Department of Health, called upon each coke or steel company represented to give a recital of their method of handling the objectionable taste-producing wastes. One of the most interesting points brought out was the fact that many of the larger steel companies producing phenol in the manufacturing processes are now keeping 100 per cent of the phenol wastes out of the stream or are building treatment works to accomplish this object. All the testimony given orally was recorded by the stenographic secretary and it is to be available for all the delegates to the conference as soon as the report has been prepared.

The coke company representatives brought out the fact that the method of evaporation of the wastes by quenching the coke, which appears to be the only practicable process so far developed, is expensive and they welcome any efforts to reach a less expensive and yet satisfactory method of disposal.

The Conference of States offered to the manufacturers present an opportunity to join the conference and effect an organization which could jointly work toward a solution of the phenol wastes problem. A resolution was passed to the effect that the United States Bureau of Mines be requested to conduct research experiments on the phenol wastes problem with a view to getting a cheaper method of wastes disposal. The United States Public Health Service definitely promised research work on phenol wastes studies in the field of public health. These can readily be carried on now at the new experimental plant recently completed by the United States Public Health Service at Cincinnati, Ohio.

The conference accomplished a step forward in the solution of this perplexing trade wastes problem in that all the evidence regarding treatment methods and magnitude of the problem was gathered both from states and manufacturers. It is the intention of this Conference of States on the Ohio River watershed to adopt some definite policy for the control of taste producing wastes which damage public water supplies, which policy can be adopted and enforced by all states alike.

Mr C. A. Emerson: There is not much to be added to the brief statement in the report. The City of McKeesport, Pa., for several years suffered periodic pollutions of its supply due to the waste from byproduct coke ovens. The fault was clear; the Steel Company admitted the fault but there seemed to be no legal remedy available in the state to handle the matter. The City asked for a temporary injunction which the court granted after argument. At the time of the granting of this injunction, the Steel Company had under way remedial measures, but the fact remains that there is an injunction on record which was secured by the City where there was apparently no State law which applied directly. Since this injunction has been in effect, the City of McKeesport has been able to operate its water works with practically no interference from these coke oven wastes. The plant is situated above the City about eight miles. It is several times larger than any other coke oven installation in that country.

Mr. A. L Fales: The so-called "Oil Pollution Act, 1924" became law on June 7, 1924. This Act provides that except in certain cases of accident or emergency, or as permitted by regulations which the Secretary of War is authorized to prescribe, it shall be unlawful to discharge oil into or upon the coastal, navigable waters of the United States from any oil-burning or oil-transporting vessel.

The penalty for violation of this Act is a fine not exceeding $2500 nor less than $500, or by imprisonment not exceeding one year nor less than thirty days, or by both such fine and imprisonment, for each offense. Clearance of such vessel from a port of the United States may be withheld until the penalty is paid, and said penalty shall constitute a lien on the vessel. Provision is also made for revoking the license of the officer of the vessel.

For the administration of the Act, the Secretary of War is authorized to make use of the organization, equipment and agencies employed in the improvement of rivers and harbors, and the officers and agents in charge of such improvements, and the assistant engineers and inspectors employed by them; and the officers of the Customs and Coast Guard Service are charged with the arrest of violators of the provision of the Act.

The Act also provides as follows:

SEC. 9. That the Secretary is authorized and directed to make such investigation as may be necessary to ascertain what polluting substances are being deposited into the navigable waters of the United States, or into nonnavigable waters connecting with navigable waters, to such an extent as to endanger or interfere with navigation or commerce upon such navigable waters or the fisheries therein; and with a view to ascertaining the sources of such pollutions and by what means they are deposited: and the Secretary shall report the results of his investigation to the Congress not later than two years after the passage of this Act, together with such recommendations for remedial legislation as he deems advisable.

For this investigation, the sum of $50,000 is authorized in addition to funds already appropriated for examinations, surveys and contingencies of rivers and harbors, which may be drawn upon.

This Act is "Public—No. 238—68th Congress (S. 1942)," and copies may be obtained from members of Congress.

THE ACTION OF WATER ON SERVICE PIPE[1]

DISCUSSION

Mr. J. M. Diven: As Mr. Donaldson well said, this committee has been very lax. The Committee thought that one of the easiest things it had to determine was what degree of hardness was necessary in water to make the use of lead pipe safe. As you have just heard, we got into very deep water. Our desire and intention is to try to standardize services; that is, to find a material for services that will meet, as nearly as possible, all the conditions, cost, durability and consideration for health. This may be very difficult, but we hope that we are going to come very near to it. It would be all very nice if every water works—Mr. Donaldson said there were some 6500, I think, in the United States and Canada—would have their water analyzed and determine for themselves just what material they required for services, but they will not do that. It is up to us to try to find some standard material that will meet almost all conditions. It will probably fail in some of them. A very large number of cities, by city ordinance, require the use of lead pipe.

Lead pipe is satisfactory from a mechanical standpoint; the cost is not excessive, and in almost all cases the life is very long, almost indefinite. But, if we are endangering health by the use of lead pipe, certainly we must find something to take its place. Galvanized iron is used extensively recently; I think galvanized steel more extensively. In first cost, this is probably the cheapest material we find, but its life is very uncertain, especially with steel pipe it is rather short in a great many cases. Personally I know of galvanized iron services, the old galvanized iron we used to get about the time this Association was formed, that I put in myself over forty years ago, and it seems to be still serviceable, but I doubt if we are getting the quality of galvanized iron and galvanizing that we got at that time.

Two unfortunate circumstances prevented your committee sending out a questionnaire to get some idea of the cost of different

[1] Discussion before the New York Convention, May 23, 1924. See Journal, May, 1924, page 649.

characters of pipe. The unfortunate condition this year was my rather sudden change in business, and perhaps more important, one might have eliminated the other, the lack of funds in the particular account to take care of it. However, we will try to do it. You all know I have a little money, and if the Association has not the funds the questionnaire will go out anyhow.

The use of small size cast iron is comparatively recent. I found at Troy cast iron service pipes that were put in from fifty to eighty years ago. They are being taken out now very rapidly and on streets that are going to be permanently paved, the cast iron services are all taken out. They are badly corroded and stoppered up so that you can take a piece a foot long and hold it up to the light and can hardly see light through it. How any water ever crawled through it is a mystery. This, however, is uncoated pipe. I think this is about all that your committee can report on now, except that we will try to be a little more vigorous during the coming year. The subject will be divided into two questions, the sanitary and the mechanical. When the mechanical data are secured, we will have to turn them over to the chemists and bacteriologists to find whether the pipe that seems, from the mechanical standpoint, the best, will stand the health test; and I assure you that the committee will try to do something this year and bring in a satisfactory report.

Mr. Wm. F. Wilcox: Did you take any particular precautions when you put in those services that lasted so long?

Mr. Diven: No, nothing except buying such galvanized iron as was in the market at the time.

Mr. Wilcox: I mean the ones that lasted forty to fifty years.

Mr. Diven: Those were the ones that did not last; I am only going back forty years; if you really want the truth, it is fifty years last November.

Mr. Wilcox: I do not want to embarrass you.

Mr. Diven: You will not embarrass me; there are different ages in life; the little child will always try to appear older; when a lady gets past twenty-one, she wants to appear eighteen, but finally we get to a period in life when we are proud of our age.

Mr. F. N. Speller: In a survey of the information on service experience such as Mr. Donaldson has compiled, it has naturally been impossible to go into very much detail in some particulars, I just want to call attention to a few points, at his kind invitation, with reference to iron and steel services. Under his heading of the "accepted facts" regarding corrosion, there are two that I would take issue on. In the first place, he states that carbonic acid is the prime factor in corrosion. The work done by Dr. W. H. Walker, whom he cites, at the Massachusetts Institute of Technology and by others, indicates beyond any doubt that in ordinary water the oxygen concentration is the most important factor, and as a matter of fact it has been shown recently by a number of experimenters, that, with natural water with a pH of between 5.5 and 9.4, the acidity due to the CO_2 content is not important excepting so far as it affects the scale forming properties of the water. I would cite, as experimental evidence on that, the fact that water, which had been deaerated by the deactivating process, is practically non-corrosive, and at the same time in removing the oxygen the CO_2 content has not been changed. There are over a hundred of these apparatuses in use in this country now, and that effect has been very noticeable.

The second "accepted fact" that I would take very strong issue with is that galvanized steel is essentially less durable than galvanized wrought iron when in contact with water. Dr. Walker, the authority whom Mr. Donaldson cites, made a very extensive survey of iron and steel services in New England several years ago, as referred to in the paper Mr. Donaldson has just read. He found, not only by laboratory experiment, but by actually locating in the field services that contained both iron and steel in the same line, that there was no noticeable difference in the long run, between these two kinds of pipe. Sometimes one was a little better than the other and sometimes it was the reverse. In that connection, other engineers have made extensive experiments in water lines, particularly in hot water, with the iron and steel in the same lines, and have not found the difference that Mr. Donaldson states. As a matter of fact, I do not think statements like that should be made any longer without experimental evidence. There is too much definite evidence from long experience which shows that the difference, if any, is very small. Now if you will permit me, I will run over briefly what seem to me to be the established facts regarding corrosion.

In the first place, both water and air must be present together, and when corrosion occurs, it is proportional to the oxygen concentration within the pH limits referred to above.

The second most important fact is that protective films on the metallic surface retard corrosion more or less; sometimes this becomes the controlling factor even more so than the oxygen concentration. There is a close connection between this fact and the pH value as referred to above.

Third, the contact effect between dissimilar materials, brass and iron, for instance; differences in concentration of ground water, or water in estuaries where sea water occasionally lies in contact with fresh water, causes accelerated action on the metal exposed to the more dilute solution. This has been found to be a very important factor in certain cases of soil corrosion.

Velocity and temperature both accelerate corrosion, as evidenced by the action of turbulent flow.

Composition has very little effect on corrosion in water, and probably underground, although we do not know so much about soil corrosion as corrosion in water and air, but there is no question that a large range of variation in composition may exist without being a controlling factor. The American Society for Testing Materials have been conducting for several years a series of tests on about twenty-five different kinds of ferrous metals immersed in various kinds of water and exposed to the atmosphere, including a range of composition from ingot iron (so-called), which is supposed to be 99.8 per cent pure iron, up to wrought iron which carries 2.5 to 3 per cent cinder and other impurities. No noticeable difference whatever has been found between these in the tests in water.

Other factors, such as the salt content of the water, over-voltage of the metal, humidity of air, and many other points are important, but the ones mentioned I think are most important. The various factors affecting corrosion in water bear a different relation to each other in alkaline, neutral, and acid water as pointed out by Mr. R. E. Wilson in a paper on the "Mechanism of Corrosion" (Journal Ind. and Eng. Chem., 15, 126, 1923). (See also "Effect of Hydrogen-ion Concentration on the Submerged Corrosion of Steel," Journal Ind. and Eng. Chem., 16, 7, 665, 1924.) The point is that there are several factors that are of importance in governing corrosion, and they have a very different relation to one another according to the pH value of the water, so that any tests made must take into account not only all

these factors, but must also have those factors present in about the same relation to each other, or it is evident that one will get very different results. This explains the difference of opinion that often exists from experience in different places. One man will be dealing with water that has a very high protective film-forming power. Another will be experimenting with neutral water where the oxygen concentration is the prime factor.

Copper in steel aids in the formation of protective film in air and, therefore, this metal lasts three or four times as long as ordinary steel without the copper. This is not the case under water, which again illustrates the fact that composition is important in atmospheric corrosion, but of very little importance in under-water corrosion.

A Member: How do you relate temperature and velocity as an element?

Mr. Speller: They are related in a way because they both have to do with accelerating all chemical reactions, and velocity helps to aid the diffusion of oxygen.

A Member: Velocity is the rapidity of chemical action rather than the flow in the pipe.

Mr. Speller: Velocity increases the rate of diffusion of oxygen to the surface of the metal; it helps to mix the water up; in this way these factors are very closely related. I like to look at the mechanism of the corrosion probem as analogous to the flow of water through a pipe. If the pipe is smooth and there are no obstructions of any kind, the water will flow at a certain rate, but if you have valves or other obstructions in the line, you have something analogous to the influence of polarization, film protection, a counter e.m.f., over voltage and the other factors that tend to retard the solution of the iron and congest the whole process. If there were no natural tendencies to stop corrosion, the damage would be very much more than we can imagine, because the solution pressure of iron in water is enormous, but fortunately we have certain natural tendencies which may be artificially controlled to a large extent. Considering the number of variables involved you can see how important it is to be careful in drawing conclusions from experience in one field of

corrosion and applying it to other fields where a different set of factors apply.

Mr. R. S. Weston: In the beginning I wish to compliment the Committee upon the excellence of its report. In its discussion I should like to emphasize the importance of oxygen in corrosion.

A very good example of the corrosive effect of oxygen is found in our town of Brookline. Formerly the supply came directly from wells and contained 32 p.p.m. of carbon-dioxide, 1.5 p.p.m. of oxygen, 0.67 p.p.m. iron and 0.2 p.p.m. of manganese. In 1914–15 a deferrization plant was built which produces an effluent containing less than 6 p.p.m. of carbon-dioxide, 0.007,p.p.m. of iron, no manganese and practically saturated with oxygen.

Prior to deferrization there was a deposit of iron and manganese on the insides of the pipes which protected them to some degree, while the services were cement lined. Consequently there was little observable corrosive action before the little action on services since. On the other hand the house plumbing was not protected and since the water has been oxygenated has suffered greatly. Tin-lined brass resists the action of even hot water, as does copper, when it is provided with insulating couplings, but the best iron or steel is short lived even when insulated against electric currents. Especially liable to attack are the horizontal hot-water pipes. Where the copper pipes are not insulated even this metal dissolves.

At Milford, Mass., where we have been observing the action of water on lead services for many years we find that a dose of about 10 parts of lime per million reduces the lead content in water drawn from a test service pipe to an average 0.085 p.p.m. and where the water is allowed to stand over night to a average of 0.27 p.p.m. Formerly the water might contain 3.0 p.p.m. of lead under conditions of ordinary use and lead poisoning was frequent.

This treatment is successful with waters having hardnesses of more than 30 p.p.m. With waters having hardnesses of less than 20 p.p.m. and derived from colored surface sources the efficacy of lime treatment is doubtful. However, our experiments show that in such cases small doses of sodium silicate afford equal or better protection than that secured by lime treatment.

We have made tests at Milford to determine the pH value of the water which had the least action on lead and so far these point to a value of 7.6 which is rather lower than the pH value of the solution

of calcium carbonate which would have the least solvent action on lead, namely pH = 8. Why this alkalinity may be lowered to correspond to a pH value of 7.6 in practice is probably because there are other protective substances present, besides calcium carbonate.

As to the permissible amount of lead in water: Here it is true that we are revising our limits downward and such sanitary engineers as Mr. Howard of the New Hampshire Board of Health protest the presence of any lead at all, while we have under observation for one of our clients a case of lead poisoning where water containing less than 0.1 p.p.m. of lead is apparently injuring the health of one individual in a large community.

Of course, there is a great deal of variation in susceptibility to lead poisoning just as there is to alcohol or any other poisoning. Some can stand a lot, others hardly any.

The most generally applicable remedy for lead poisoning is to use cement lined services. In the second technical paper I ever wrote, which was over twenty-five years ago, I advocated these services. I still do and I am glad to see the day when improved pipe of this type may be purchased of the maker and shipped by truck or rail to the user.

A new possibility is the use of small cement-coated, cast-iron pipe in place of cement-lined, wrought iron.

Wooden pipe must not be forgotten and where it is permissible for structural reasons obviates all corrosion troubles.

In all studies of corrosion by water it must be remembered that pure water has practically no action on metals. It is the foreign substances,—like oxygen, carbon-dioxide, calcium, "hardness" and alkalies, —which make the water corrosive or non-corrosive and consequently the determination of its properties by analysis and experiment is a necessary preliminary to the choice of a material for service pipes.

Mr. David A. Heffernan: Mr. Donaldson has given much time in the preparation of his most interesting and instructive paper and there is no question in my mind but that what he has said will be of benefit to his listeners.

He is right when he says "there is no one-best pipe" applicable to all conditions. Economy of installation and maintenance are paramount issues in service installation. But there are times when a saving in the cost of installation is permitted to overshadow the

postponed cost of maintenance. The ideal material for delivery of water from main to meter is the one which will give the greatest length of service at the least expense of installation and repair.

The cost of the pipe is the smallest contributing factor outside of the fittings. The cost of excavation, back-filling and replacement of pavement is from 40 to 70 per cent of the entire cost, varying of course with the soil material, kind and grade of pipe, etc. Some waters have affinity for pipes of certain materials and these may be easily determined and avoided. It is not in my province to recommend what pipe should be used, but I would like to say a few words about my troubles and the remedies I found.

Without going back too far I will say that twelve yeas ago we found that lead and galvanized pipes were not suitable to the water with which we were supplied and I began to use black wrought iron pipe lined with cement to the exclusion of other materials. The pipe itself has given excellent service, but at points where it entered a brass stop or fitting we often found the pipe at the thread eaten completely away and the fitting almost filled with deposited material, resulting in badly weakened pipe and many complaints of poor pressure.

To overcome this I devised forms for lining stops and fittings with lead. Now we have a service in which from main to meter, the water passes through walls of brass, lead and cement. No water comes in contact with iron at any point after it leaves the main. The difference in potential between brass and lead is small enough so that we need not worry about violent galvanic action between these metals.

We use black wrought iron pipe plugged and reamed, in about 15-foot lengths. Natural Rosendale cement was found best for lining because it sets much more slowly than Portland and, therefore, does not require as frequently mixed batches. The lining apparatus consists of a screw piston ram or gun, set above a bed in which the cement is mixed, and a cone which is pulled through the pipe after being filled with cement, making the waterway. The cement after being mixed in the bed is used to fill the gun. When operated it forces the cement into the pipe which is screwed into the end of the gun. The pipe is then removed and placed in a vise which is conveniently placed and the cone attached to a long leading wire is pulled through. The cones are made in such sizes as will allow a one-eighth inch coating all around the inside of the pipe.

After being allowed to set up for four or five days the ends are turned up, the pipe cleaned and given a coat of tar paint.

The successful use of cement-lined pipe demands careful installation. Wheel cutters should not be used when breaking lengths. We use a square edge cutter. A file is also used to make certain there are no ragged edges.

I feel quite sure that carefully installed cement-lined pipe used in connection with lead-lined fittings and stops is the pipe for services which will give most satifactory results under the widest variety of conditions.

Mr. Wm. G. Schneider (Copper and Brass Research Association, New York): The last paragraph of Mr. Donaldson's paper on water service pipes refers to brass when used for such purpose. It is true that brass for service lines has not been extensively used. This is due to the fact that it has not received the consideration which it deserves, and that it is a new comer in this field. That it will be more extensively used in the future is certain, especially as its many advantages become more apparent.

A comparison of its advantages, and disadvantages, if any, with the other piping materials discussed in Mr. Donaldson's paper makes it obvious that brass and copper pipe do deserve consideration, not only for certain service pipe installations, but also for plumbing pipe.

Mr. Donaldson points out that galvanized pipe soon rusts and corrodes, becomes rust-clogged, and that red water appears at the faucet. Brass and copper pipe do not rust or become rust-clogged and no red water is discharged at the faucet where it is used, provided the plumbing pipe in the house is also of copper or brass. Brass pipe is easily installed, and presents no difficulties in its handling that are not experienced with galvanized pipe.

Annealed copper pipe is used for service lines and is a most satisfactory installation. In addition to its resistance to corrosion it is ductile and therefore may be bent to the main, eliminating the lead gooseneck.

Brass or copper does not have the serious drawbacks that are experienced with lead, as brought out by Mr. Donaldson. There are thousands of installations of brass or copper plumbing pipe in this country, but not a single complaint is recorded against these materials from a sanitary or health standpoint.

Any apparent disadvantage of greater initial cost for brass or copper is not a serious factor when carefully considered. Compared to galvanized iron, brass or copper pipe costs slightly more than twice as much. When installing service pipe the cost of the piping material is a very small part of the final cost of the job. For example, a comparison of costs of galvanized iron, brass, copper and lead services based on a 50-foot length, without connection to main, gives the following:

	IRON	BRASS	COPPER	LEAD
1 inch pipe and fittings	$6.50	$23.50	$26.00	$22.00
Assumed cost of installing at $3.00 per foot*	150.00	150.00	150.00	150.00
	$156.50	$173.50	$176.00	$172.00
Cost of pipe and fittings *per cent*	4.15	13.55	14.75	12.80

* Where resurfacing necessitates exceptionally fine pavement the $3.00 charge may be much higher.

Taking the galvanized iron installation as a base:

Brass costs	about 10.9 per cent more
Copper costs	about 12.5 per cent more
Lead costs	about 9.9 per cent more

The above costs for brass pipe are based on mixtures regularly supplied for plumbing purposes. Where such mixtures are not suitable, due to exceptional water conditions, such as the circulating of sea water, the prices quoted for copper approximate the cost for the higher copper content brass pipe.

In other words, the house owner may install copper or brass service lines for about the same cost as lead, with none of lead's disadvantages. Where the installation costs $100 with galvanized iron, copper or brass may be installed at an additional cost of about $12, giving a permanent installation free of rusting or rust-clogging that will not require subsequent replacement.

Mr. Wellington Donaldson: In connection with the subject of lead solvency, certain data reported by Bunker (in a paper in Water and Water Engineering, January, 1923) are interesting. These figures deal with the Agua Clara supply of the Panama Canal Zone, which, after being treated with soda-ash and alum, aerated and

settled in basin, has a pH value of 5.5, 4 p.p.m. alkalinity and 4.5 p.p.m. CO_2. Filtration followed by a lime dose of 0.3 g.p.g. results in pH 9.0, alkalinity 15, monocarbonate alkalinity 3.0 p.p.m. Bunker found that even with this amount of monocarbonate alkalinity, 0.5 p.p.m. lead was taken into solution from new services during the first three months after installation, although 0.1 p.p.m. was the maximum amount present in conditions of ordinary day use from old services. These results were considered sufficient grounds for the recommendation to discontinue use of lead service pipe for the Agua Clara supply, although no cases of plumbism were known to have occurred.

Another interesting result reported by Bunker was that traces of residual chlorine in the filtered water did not increase plumbo-solvency.

Illustrating the unsuspected existence of plumbo-solvency in many communities, where special attention has not been given to the subject, is the case of a town in South Carolina, recently reported by Morrison in "Water and Light" of April, 1924 issue. Here the water supply, derived from wells 40 to 60 feet deep, is "unusually soft and pure." Lead goose-necks or service connections, "extra heavy," began to give way after seven year's use and when examined were found to be nothing but a shell, pitted on the inside like small-pox. Lead joints in the water mains were similarly attacked. Feeding soda-ash at a dosage of 1.2 g.p.g., during the past four years, has apparently stopped corrosion of lead in the distribution system. The existence of possible lead poisoning in the city was not discussed, and one is left to his own speculation as to whether such relatively large amounts of metallic lead can be dissolved in seven years' time without detrimental effect on consumers.

The case just cited is by no means an isolated one, but serves to emphasize the importance of water works operators, having to deal with soft supplies high in color or carbonic acid, making a careful investigation to determine the action on lead and applying remedies necessary to establish immunity from possible poisoning.

It is of considerable significance that the revision of the United States Treasury Department standard for quality of water furnished by interstate carriers takes cognizance of metallic and mineral impurities as well as bacteriological condition.

The practical effect of this standard would be to direct attention to metallic content of water supplies which heretofore has been in large part neglected both by the water analyst and by health officials.

DISCUSSION OF REPORTS OF COMMITTEE NO. 7 ON PUMPING STATION BETTERMENTS[1]

Mr. Leonard A. Day: The work of the Pumping Station Betterments Committee this year consisted mainly in the preparation of four papers relating to our subject. The first paper which was written was the selection of auxiliaries for steam operated pumping stations, by F. G. Cunningham;[2] The second is "The Electric Pumpage at Kansas City," by A. L. Maillard,[3] the third was "Some Experiences with Steam Turbine Driven Centrifugal Pumps,[4] by the speaker, and the fourth was "Diesel Engine Driven Pumping Station" by W. DeW. Vosbury.[5]

Mr. J. N. Chester: With the Diesel engine paper[5] just read, fresh in my memory, I shall bring out such points as impressed me in that first, and will then revert to those I will discuss from the printed page. Having had no experience with Diesel engine drive pumping stations, but the nearest being with gasoline and natural gas actuated engines, I can only draw some conclusions and comparisons from that source. My first mention is this: we have several gas engine driven pumping stations. We resort to gasoline only when the gas during the winter time goes short, and the one thing is the difficulty of obtaining men in an emergency to operate those engines. True the automobile expert has made this field a little more fertile than it formerly was. Notwithstanding even that, where you have a station in which only one engineer is needed, it being a reservoir, and, with an eight hour shift, a supply can be pumped, when that engineer goes down there is sometimes a hustle and a difficulty to find somebody to take his place. That has happened to the extent that we have adopted the plan that the superintendent himself must be a competent gas engine engineer, and he is the man who must alternate with the engineer when the engineer is out of service.

[1] Presented before the New York Convention, May 23, 1924.

[2] Journal, March, 1924, page 341.

[3] Journal, May, 1924, page 542.

[4] Journal, May, 1924, page 548.

[5] This Journal, page 381.

Naturally in the paper where it has been shown that electricity was produced at five-tenths of a cent or five mills per kilowatt, we can only decree that that operating cost, plus a fair maintenance, must be considerably less than usual. It would seem to me that, within the zone of our large centrally organized electrical properties, the Diesel engine driven pump would hardly be practical, and especially when you add the burden, that it would add, to the conclusions drawn by the author of this paper.

When we first began incorporating in the equipment of our plants a Ford machine, we were led to believe by Mr. Ford's agent and others, that the machine was a four year entity and that we should figure the depreciation accordingly. Ten years employment of that creature has led us to the plan of turning in our Fords at the end of the second year and receiving therefor $125 in credit on a new machine; consequently we depreciate them now on the two-year basis with a junk value of $125. Now to the author of the Diesel engine paper and to others contemplating it, I believe you are going to find the Diesel engine something in the line of the Ford machine. I can only give you as a point to serve my argument the fact that fifteen years ago, at Edgeworth, Pa., we installed as high a grade of gas engine driven equipment as it was possible to purchase, and for four or five years we ran along with practically no maintenance. There was the grinding of the valves and little wearing parts and all those things that you fellows who run automobiles know about, and then amortization set in in earnest, and when I tell you that, when we passed the tenth year, maintenance of the equipment in the last five years for every year has far surpassed the other operating expenses, that is, it has surpassed the cost of the fuel and the cost of the men to operate that station. Last year it was five thousand dollars, and it is only the fact that that situation is hanging along because the Pennsylvania Railroad has surveyed a six track right of way right across it and expects to give the company a new station for the old one, that we have tolerated that kind of maintenance cost. I tell you that so that you will not think we are crazy for not having replaced it before, but I think 15 years is probably a high average life for the Diesel engine. I fear that within that time, like the Edgeworth, Pa. gas engine driven station, the cost of maintaining that plant will have mounted to a place where you will be convinced that the useful life of that kind of equipment, especially the Diesel engine itself, is closer to ten than fifteen years.

With regard to Mr. Day's paper on Turbine Tests,[4] that struck me as a very interesting and exceedingly extraordinary phenomenon to have occurred. Associated for many years as I have been with the turbine driven equipment, we arranged through Mr. Biggs, the Chief Engineer of the American Water Works and Electric Company, that a second test be made of the turbines at Birmingham, Ala., which was done. Absolutely contrary to Mr. Day's experience at St. Louis, no such interferences with economy were discovered. In fact the second test a year after was approximately the same as the first or the original.

The second test simply verified the first. In other words, the test of each engine was just a little different from the orignal test for acceptance, and made on the same basis as the original test for acceptance of those machines, indicating practically no change in the turbine economy within that year, and no scaling or corrosion.

At Erie, Pennsylvania, we have been unable to find anything of this kind. Both stations use superheated steam, and if I had been told of this without seeing Mr. Day's tabulation of the test, wherein some 80 degrees of superheat was used, both during the formation of this scale and during the test afterwards, my first question would have been, "Why not superheat the steam and thus remove all evidence of scale?" Further than that I would not have been able to comment. It is a mystery to me just how it gets through at St. Louis, even though Mississippi River water is there used. At Erie we have lake water and at Birmingham they have water from Lake Purdy and the Catawba River, which seem to me are all the same when you get them into superheated steam.

Mr. Cunningham's paper on Auxillaries for Steam Operated Pumping Stations[2] is what I would call a good general outline and discussion of pumping station auxilliaries. It is splendidly prepared and certainly brings the subject before the unthinking, at least, in a way that will cause them to study and give more attention to the selection of auxiliaries. As I go around the country and visit different stations, it seems to me that that is the one thing that has been ignored, or that has been generally left to the manufacturer, who, we will say, generally puts in the kind of a condenser, air pump or circulating pump, which is the nearest on the shelf when he selects the machine he is going to offer. Out in the engine room or the boiler room you will find the kind of a boiler feed pump that the most adroit salesman has been able to offer to the operating engineer or the superin-

tendent. I cannot better illustrate that than by saying that I found a good many non-conducting turbine driven boiler feed pumps in small stations, which I consider is about the limit of benighted ignorance in boiler feed pumps or boiler room practice, for the ordinary sized water works.

We also find a good many electric light units operated by non-condensing turbines. Now if you have a large pumping station and directly connected everything in that room and a big boiler plant and no other means of obtaining boiler feed water heat, we might justify such equipment, but in every case where I found these I believe I found a goodly portion of steam shooting out through the exhaust, having first passed through the heater. I simply bring it up to show the extreme in one direction.

The heat balance brought out by Mr. Cunningham is based, we believe, on a new station, which unfortunately few of us have the opportunity to design and create. Ninety per cent of all the engineer's activities are in designing additions to old stations, and therefore we must first consider what we have, and then compute the makeup in the new equipment. My discussion is more generally on the differences I have with the author of the paper than praising its good points.

Take the matter of heating the station, which I never consider in determining heat balance. Heat for the station is seasonal, and if you consider it and balance it for the winter time, you are out of balance badly in the summer time. I argue therefore that, if I can recover or salvage the hot water from my heating system and get it back to my heater, since we use steam for heating only in the winter time, and I can then put that much extra back, I can just about provide the additional heat needed in that best balance due to radiation of cold weather, over what we would need in the summer time. We generally forget, therefore, the amount of heat required to heat the station or the filter building or anything else round about, and simply say we will have that as a contribution in the winter time to make up extra radiation.

My differences with Mr. Cunningham and the impressions that I have gained from reading his paper are principally in the condensing equipment. There has been brought forward in the last year or two, especially in turbine driven equipment, the matter of the extension of the shaft and the addition of a circulating pump and the use of what he terms the Marine type of condenser. To me this is the

ordinary type of engine room condenser wherein the circulating water goes through the tubes, instead of, as in the water works type, where it goes around the tubes. With something over 200 pump installations to my credit, I must declare I have never found occasion to use but once any other than the water works type of condenser. I feel a good deal like the fellow who was quoted $2500 on a sawmill for sawing up a certain piece of timber and wrote back to say, "If I had $2500 what do you think I'd want of a sawmill?" And if I have a water works problem of 20,000,000 gallons and under, I can only reply, "what do you think I need with a circulating pump when I can place that condenser in the suction or discharge and utilize the water pumped by the main engine for circulation purposes?"

I am not going to say for a minute that, if I put in a pump of 110,000,000, as I believe Mr. Day has to lift the water out of the Mississippi River to the settling basins, I would consider a water works condenser. I know I would not. The volume to go through the condenser has much to do with the problem and when the cooling capacity is so small in proportion to the amount of water that must pass through naturally, we go over to the other type of condenser. Let me state here that my installations to date have been limited to a capacity of 30,000,000 and I have always found means of making the water works condenser applicable, although I have given study to the other type.

Let us consider the low service pump; we are drawing our supply from storage or a running stream and have more or less trash trouble; we naturally say "screen it out," but when you take that water, even out of your suction, and try to drive it through the tubes and the condenser, you will find there a screen that is constantly stopping up, for strain the water as well as you can, you will have sufficient material left to stop up the tube head in the power type of condenser. It is not easy to clean, but if you put it through the water works type, you will not need to clean it, because any water works type of condenser should pass through to the settling basin anything that would pass the screens, where the other condenser would arrest it and necessarily you would have to shut down to clean. I have seldom been confronted with the necessity of supplementing feed water heat by drawing from the boilers. I generally find more trouble in providing some means of disposing of what I have left from the auxiliaries and prefer to generate within the station the electricity necessary to light that station, even though it could be bought at a very reasonable

price, and so use the exhaust steam from that engine to make up my heat balance, rather than to draw direct steam from my boilers, or, we will say, from the intermediate stages of our pumping equipment. I do not like taking steam from the receivers of either the turbine or the pumping engine unless I know that the same amount is to be withdrawn or in the same proportion to the horsepower that that machine is generating. That I have not found possible, because some day when you are pumping slowly with one machine you are drawing from and pumping hard with some other machine and you are throwing that machine out of balance by taking the steam from its receiver. I have frequently found reason to use a pressure heater and put a little back pressure on my auxiliaries and discharge the steam waste or heat back into the receiver of some engine and thus shorten up the cutoff, and get the benefit of it in that way rather than taking out enough to make up a deficiency.

This is a long paper and contains a good many other things in the way of stokers for coal handling equipment, and such things that do not interest many of you. It is only in the larger stations that you put in stokers. It is only in the larger station that you have coal and ash handling machinery, and in as much as there are as many different methods of driving those elements as there are different types of machines made, of course, steam driven equipment is applicable whenever your equipment permits, but we have the water wheel and electric motor and other ways of driving, and I am going to arrive at the same conclusion that Mr. Cunningham reaches, to wit, that every different boiler and engine room is a problem by itself.

Mr. Kerr (General Electric Company, Steam Turbine Department): The experiences of Mr. Day have been the subject of a great deal of study by turbine manufacturers. We have to furnish turbines for operation under a variety of conditions in various parts of the country, and it really comes down to a question of feed water conditions. The first thing we recommend is a rectification of feed water conditions. Another thing is the proper separation of foreign matter between boilers and turbines. Now we must bear in mind that superheated steam does not necessarily mean clean steam, neither does it necessarily mean dry steam. Under ordinary conditions, yes; but under sudden fluctuations or things of that kind, no. We have no control other than to make recommendations concerning the water conditions. Therefore, our

method of attacking the problem has been to make our equipment as accessible as possible. We have split all the stationary elements of the turbine; that includes the casing, the diaphragms and the packing. We have separated the external shaft packing boxes from the casings, so that with moderate attention, which one would expect to give to machinery and an inspection with a frequency depending upon the conditions under which the turbine is operating, there should be no difficulty such as experienced by Mr. Day. There will be deposits, but, if the inside of the turbine is inspected once in a while, the deposit does not reach such an extent that it cannot be removed easily. Of course, that is the trend of modern design of any kind of mechanical equipment, whether automobiles or anything else, because we realize that anything mechanical is not 100 per cent right, and we must be able to get into it and look at it. I might say here that these experiences are not confined to any one class of installation, or any one particular make of turbine. We find it in our central station practice. Central station men have come to realize it and I might further say that the accessibility feature of the turbine has not been solely because of the desire of the manufacturers, but by the demand of the trade.

There is another point that came up in Mr. Chester's discussion of Mr. Cunningham's paper, and that is the queston of extraction from turbines. I believe, of course, it depends entirely on each individual station, but the central station men have found this to be more desirable than depending upon steam from the auxiliaries, because they have absolute control over it. Of course, as I said, this is subject to variation in individual plants.

Mr. Isaac S. Walker: The hour is getting late and I do not believe I have anything to offer at this time of special importance, other than that Mr. Vosbury had a rather strenuous time of it when he started this Gloucester Diesel Engine pumping station in operation. Perhaps a word from him on that might be of interest, as he did not elaborate on it to any great extent in his paper.

Mr. W. De W. Vosbury: As Mr. Walker has intimated, we did have a strenuous time in starting the Gloucester plant. A great deal of dissatisfaction existed among the employees. They were men who had experience in steam operated plants only; consequently they looked upon the new Diesel plant with distrust. In addition, it was known that there would eventually be a reduction in the

number of operators and that at least one-half of their number would lose their positions.

I would not want to say that there was any ulterior motive in their attitude or that there were any direct attempts to discredit the plant. There were rumors circulated however, which came very nearly convincing the public that the new plant was too complicated and that it would not run or at best that it would prove to be unreliable.

A few weeks after the plant has been in operation the governing body of the municipality introduced and passed an ordinance reducing the number of employees at the station from fifteen to seven. Within a few hours following the passage of this ordinance word was received that the men were going out on a strike and that the plant would be unattended. To relieve the situation I sent for one of my assistants who had supervised the construction of the station and was therefore thoroughly familiar with it. This one man operated the station unaided for nearly three days and at no time did he require the aid of an assistant, as there was very little to be done. The station practically runs itself.

The only regular duties of the attendant, outside of occasionally filling the auxiliary fuel oil tanks is to watch the temperature of the cooling water, keep the equipment clean and to change over the pumps now and then to conform to the variation in demand.

After an engine has been in continuous operation for a period ranging from six to eight weeks it becames necessary to shut it down for over-hauling. This consists principally in the grinding of the valves and minor adjustments. An inspection is also made of the main bearings. Now that everything is running smoothly some of the incidents which occurred during the first few weeks of operation are, upon reflection, very amusing.

One such incident occurred shortly after the strike, which I have referred to above. It had to do with the engine which had been giving trouble in speed regulation. Even after the source of the trouble had been found and eliminated it was apparently impossible to keep it in operation for a period longer than a day or two. Finally, however, with a change in operators the trouble apparently ceased and the engine continued to run. To make a long story short, it ran for so long a time that I began to wonder. Finally a request was sent to my office for someone to come to the plant and shut the engine down. The truth of the matter was that it had continued to run because the new operator either did not want to assume responsibil-

ity or did not know how to stop it. Once a reputation for reliability had been established by this engine we nad no further trouble with it.

Mr. James E. Gibson: I do not think that I can add anything to this discussion. The paper is very full and had been discussed very ably. There is one thing, however, that we must all bear in mind and that is continuity of service. I mean service to the people. When we are operating a water works plant we cannot look too longingly at the economical standpoint. It is a good thing to have economy in mind at all times, but continuity of service should be our watchword, for when we do not get water to our consumers they are not going to take excuses based on an economy standpoint, and more than likely their reply will be that they are paying their bills and they want the water.

Mr. R. D. Hall: I was much interested in Mr. Cunningham's paper and in Mr. Chester's shelf of condensers to which you just reach up for appliances to your engine. My experience more or less coincides with his, at least on reciprocating pumping machinery. It is the exception rather than the rule. In fact, I cannot recollect when we have installed anything other than water works types of condensers on a municipal pumping unit of the reciprocating type. I think the Marine type of condenser was coupled rather with turbine practice, and in that respect has crept into steam turbine driven centrifugal installations. I do not imagine that it will survive to the extent that the water works type of condenser will. As far as the same shelf goes, we ordinarily equip the units in formal installations with what the engineers ask us to do, but the specifications at present are almost entirely confined to the water works type. I could quote Mr. Chester again, which he forgot to say, that in the past there has been altogether too much attention given to the refinements of the main unit, the primary mover, and too little attention to trimming our sails with respect to steam consumption of auxiliaries. I think that the future development of the art will take great cognizance of economy of low service units. The field for improvement in low service units with respect to steam economy is very great and more or less unexplored on the part of pumping machinery manufacturers.

Mr. L. F. Adams (General Electric Company): Mr. Cunningham states that electrically driven apparatus should not be used where absolute continuity of service is required, as for condenser auxiliaries of high service pumps delivering water directly into the mains.

It does not seem that the question of reliability of the auxiliaries in a steam driven pumping plant could be of more importance than it is for the auxiliaries of a large steam generating station. In the latter, the present trend is towards the elimination of the small steam driven auxiliaries and the use of motor driven auxiliaries. The conditions which have caused this trend in large steam generating stations should apply to a great extent in steam operated pumping stations.

Mr. Cunningham also mentions the possibility of interruption in electrical power circuits due to the blowing of fuses and similar causes. It is not desirable to include fuses in any of the axuiliary circuits, but to protect the motors by means of overload relays, preferably of the thermal type, so that the motors would not be shut down unless dangerous overheating occurred. A reliable source of power can be secured for these auxiliaries.

In the case of large steam driven pumping units, one of the best methods would be to have a generator connected to each main unit, this generator supplying power for all the auxiliaries of that unit and possibly large enough for the auxiliaries of more than one unit. This method enables the steam required for generating power for the auxiliaries to be used in the most efficient unit, which is the large turbine driving the main pumps.

Where the pumps are run at constant speed, alternating current can be used, but where the main pumps are run at varying speeds, direct current is preferable, as by selecting the proper generator, the voltage can be held throughout the entire range of speed. Where auxiliary power is generated in this way, it is usually necessary to have one stand-by unit connected to a non-condensing turbine so as to enable the plant to start up after an entire shut down. This should give a system using motor driven auxiliaries equally as reliable as any system using steam driven a uxiliaries.

Mr. A. Peterson (DeLaval Steam Turbine Company): Mr. Cunningham should be complimented on his paper, which is very well written and complete, and I fully agree with him that the purchaser should specify definitely what kind of auxiliaries he wants.

As regards auxiliary turbines for high steam pressures and superheats, there are today available such turbines that are mechanically just as reliable as the main units.

From the comparative power requirements of condenser auxiliaries, as tabulated on page 353 of the March, 1924 Journal, I note that the water turbine for driving the condensate pump has an efficiency of 87.5 per cent, which looks rather high for a 7 h.p. water turbine.

I assume that the power required by the hydraulic air pump, using water from the mains, should be 5 water horse power instead of 5 b.h.p., and the same should apply to the water turbine driven centrifugal condensate pump, using water from the mains. This pump requires 2 b.h.p. and based upon 50 per cent efficiency of the water turbine 4 water horse power should be charged instead of 4 b.h.p. The amount of steam charged against the main unit, however, is correct.

Regarding boiler feed pumps, while centrifugal pumps for capacities below 100 g.p.m. are not very efficient, such pumps have, however, been built, which are perfectly satisfactory, both mechanically and in maintained efficiency. The writer is familiar with small centrifugal boiler feed pumps, which have been in continuous operation for more than ten years, delivering less than 50 g.p.m. The width of the impellers at the periphery is more than a quarter of an inch and no trouble has been experienced with erosion or scale deposits.

I am sorry that I did not have more time to prepare a discussion, but as stated above, the paper is so well written and complete that there is really not much left to discuss.

DISCUSSION

TOTAL ALUMINA IN WATER (MODIFIED ATACK'S METHOD) COLORIMETRIC DETERMINATION

Reagents

1. Three-tenths per cent aqueous solution of alizarin red S (alizarin sodium monosulphonate).

2. Five per cent ammonia water free from alumina. Reagent ammonia must be distilled and kept tightly stoppered in hard rubber bottles.

3. Alumina free water for comparison standards (less than 0.06 p.p.m. Al_2O_3). The same type water in which the alumina is to be determined is allowed to stand in a fairly warm place for at least forty-eight hours and then filtered through packed asbestos. It is well to use a glass cylinder 2 inches in diameter by 12 inches long for the filter. Grind a $\frac{3}{8}$ inch hole in the base, in the center of the cylinder for a rubber tube connection. Place a perforated porcelain disc in the bottom of the glass cylinder and pack asbestos on top—the coarse first and then the fine. The depth of the asbestos should be at least 2 inches. Maintain at least 4 feet of head on this filter by means of a glass tube and rubber stopper connection in the upper end of the cylinder. The glass tube is connected to the lower end of a large funnel or similar reservoir which should be placed about 4 feet above the filter. The rubber tubing which connects the lower end of funnel with the upper end of the glass tubing should have a clamp with screw adjustment over it—this acts as a rate controller. The filtered water should be tested for alumina by using the method and comparing with standards—one made with distilled water and no alumina and the other with distilled water and 0.005 mgm. alumina (0.5 cc. of an aluminum sulphate solution, 1 cc. of which = 0.01 mgm. Al_2O_3).

4. Twelve per cent sulphuric acid. This should be made from the highest grade reagent acid and boiled distilled water.

5. Fifty per cent acetic acid made from the highest purity glacial acetic acid and boiled distilled water.

6. Aluminum sulphate solution for comparison standards. Dissolve 0.326 gram of 17 per cent filter alum (which is very white) in 500 cc. of boiled distilled water. One cubic centimeter of this solution = 0.1 mgm. Al_2O_3. This is too strong to use. Dilute 50 cc. of this strong solution with 450 cc. of boiled distilled water. One cubic centimeter of this solution = 0.01 mgm. Al_2O_3.

Procedure

To 50 cc. of the freshly collected and well shaken water add 1 cc. cc. of 12 per cent sulphuric acid. Boil the solution down to 40 cc. in a flat bottom spherical-shaped flask. A flask of 200 cc. capacity with a mark to show when the solution has been reduced to 40 cc. should be used. Add 1 cc. of 0.3 per cent alizarin red S solution and just barely neutralize by adding, drop by drop, 5 per cent ammonia water. When the solution is neutral, as indicated by the change from yellow to purple, add exactly 0.3 cc. excess of the ammonia and boil two minutes, remove from the hot plate, add 0.1 cc. ammonia and cool quickly by placing flask in a shallow pan containing ice water.

When the temperature has dropped to 20°C., add 1 cc. of 50 per cent acetic acid and compare with standards which have been treated in exactly the same manner. It is very important to make comparison within one minute after the acetic acid has been added.

F. O. BALDWIN.[1]

[1] Superviser of Water Purification Plant, Department of Public Utilities, Richmond, Va.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Third Annual Report, Ohio Conference on Water Purification, 1923. 1924; 90. Activities of Phenols Committee regarding progress in efforts to correct contamination of water supplies by wastes from by-product coke ovens are outlined, and practical problems at various plants in state discussed. Important conclusion reached was that individual administration of iodine for prevention of simple goiter was preferable to medication of water supply. **Water Purification at Toledo, Ohio, 1916–1923.** R. W. Furman. 33–8. Maumee River water is subject to extreme variations in quality; great difficulty is experienced in effecting coagulation, up to 10 grains of alum per gallon being required. Secondary coagulation is not effective. When turbidity of filter influent is much in excess of 25 p.p.m., filtration efficiency is impaired. Combined softening and coagulation with lime and sulfate of iron in 1915–6 resulted in incrustation of sand and deposits of calcium carbonate in filter underdrains and piping, necessitating reconstruction of filters. Subsequent use of lime and iron sulphate again resulted in deposits of carbonate on sand grains, a large part of which was removed by employing aluminum sulfate as coagulant. Lime and iron sulfate is now used for 5 months and alum during remainder of year. During winter of 1919–20 disagreeable tastes and odors occurred as result of anaerobic decomposition of organic matter, due to prolonged ice-bound condition of river. **A Study of the Behaviour of the Carbonator of the Defiance Water Softening Plant.** H. T. Campion. 39–42. During past year 200 pounds of coke were consumed per million gallons treated, cost for coke being $1.29 per million gallons. Gas is applied through filtros plates under 10 feet of water; approximately 80 per cent of carbon dioxide delivered is absorbed. Average analyses of water before and after carbonation, former after softening with lime, coagulation with alum, and settling, and latter after filtration, were respectively: alkalinity (total with methyl orange) 52, 53; basicity (monocarbonate alkalinity) 42, 0; causticity (hydrate alkalinity) 10, 0; free carbon dioxide 0, 2.5; total hardness 130, 135. Influent to carbonator contains finely divided white turbidity which cannot be removed without liberal doses of coagulant. Carbonation dissolves this turbidity and improves flocculation of coagulant, facilitating filtration. Little or no change has occurred in sand during two years of operation. **Investigation of Difficulties in Properly Chlorinating the Filtered Water During the Summer Months at the Toledo Filtration Plant.** R. W. Furman. 43–6. For several years,

city tap water has shown greater number of bacteria per cubic centimeter (particularly the 20° count) during summer months than chlorinated filtered water leaving the plant. Non-spore-forming gas-formers which ferment only after 48 hours incubation, but respond to all usual confirmation tests for B. coli have also been noted in treated water. Chlorine applications of 0.5 p.p.m. have failed to,remedy the condition. Double chlorination at widely separated points is a promising solution to problem. **Further Studies on Comparison of Double Coagulation and Single Coagulation of Ohio River Water at Portsmouth, Ohio.** F. E. Sheehan. 47–61. Portsmouth plant consists of two settling basins operated in series; 8 rapid sand filters; and sterilization equipment. Experiments were carried out varying method of applying coagulant; present practice of double coagulation, adding 60 or 75 per cent of required dose in first basin and remainder in second, was found to be most efficient and economical. Application of total dose in primary basin did not produce uniformly satisfactory filter effluent; while its application in secondary basin gave satisfactory efficiencies only when B. coli content of raw water was less than 10 per cc., and unduly increased burden on filters. Ohio River water averaging 50 B. coli per cubic centimeter may be successfully treated by double coagulation, sedimentation, and filtration, independent of sterilization process, which may be employed as a true factor of safety. A practical limit for B. coli content of filter influent under such conditions would be 80 per 100 cubic centimeter. Bacterial counts at 37° indicated somewhat higher removals than those at 20°, and B. coli tests showed highest efficiencies. **Method of Carbonation of Lime Softened Water Proposed for Use at Columbus to Prevent After-Reactions, Deposits on the Sand Grains in the Filters, and Deposits in the Distributing System.** Charles P. Hoover. 62–3. Excess carbonation of portion of supply and subsequent mixing with balance proved unsatisfactory. Experiments indicate that chimney gases, after scrubbing, are sufficiently pure for carbonation of softened water; as carbon monoxide is comparatively insoluble and sulphur dioxide easily removed by washing. Details of the diffusers, consisting of cemented sand, are given. **What Constitutes Good Laboratory Technique in Bacteriological Examination of Water? A Discussion and Demonstration.** C. T. Butterfield. Proper procedure is described for preparation of pipettes, sterilization of glassware, collection of samples, adjustment of media, plating, inoculation of tubes, making dilutions, incubation, and confirmation and interpretation of fermentation tests. Sterilization of glassware should consist of heat treatment at 170° for at least 1½ hours. Recommended pH range for media is 6.5 to 7.2, preference being given to pH 6.8. Final reaction of Endo media should be pH 7.8–8.2. Samples should be diluted to give plate counts between 30 and 300. **Progress in Studies of Limitations in Efficiencies of Water Purification Processes.** H. W. Streeter. 67–9. Studies of relationship of sewage pollution to purification plant efficiency, begun prior to the war, will be resumed. Investigation will consist of operation of experimental rapid sand filter under conditions permitting accurate control of quality of raw water, and intensive study of operation and efficiencies of 16 representative purification plants. **Corrosion.** C. W. Foulk. 70–5. From pH 5 to 11 rate of corrosion is independent of hydrogen-ion concentration, controlling factor being concentration of dis-

solved oxygen and its rate of replenishment in film immediately adjacent to iron. Oxygen oxidizes ferrous hydroxide to ferric, destroying equilibrium and facilitating further solution of iron, and also oxidizes liberated hydrogen which otherwise would have polarizing effect. At pH greater than 11, polarizing film is removed by oxidation as rapidly as formed; while below pH 5, film is destroyed by escape of hydrogen as gas. Rates of corrosion (sub-aqueous) of wrought iron and steel are approximately equal. Methods of prevention include; encouraging deposition of protective coating by the water; removing dissolved oxygen; and, in boilers, use of zinc plates with or without applied current. Brittling of boiler metal is caused by presence of large amounts of sodium carbonate, and may develop when permutite-softened water is employed. **Simple Goiter—An Iodine Starvation Disease.** 76–82. Occurrence of iodine in nature and its relationship to simple goitre is discussed. Use of sea salts in toto, as condiment, is suggested as means of correcting deficiency of iodine in modern diet. Average salinity of sea water is 3.4404 per cent consisting of sodium chloride 77.8 per cent, magnesium chloride 10.9 per cent, other compounds, including sodium iodide, 11.3 per cent. Iodide is seldom present to any extent in natural salt deposits owing to its great solubility, and, when present, is usually removed by refining process. **Endemic Goiter as a Public Health Problem.** O. P. Kimball. 83–5. The most important facts regarding the thyroid are summarised; relationship of iodine occurrence to prevention of goiter discussed; and administration of iodine as prophylactic measure reviewed. Approximately 1 mgm. of iodine per day, or 100–200 mgm. administered twice yearly, is sufficient to keep the thyroid saturated and prevent goiter. Adolescent goiter can best be controlled through the schools. Treatment of water supply with sodium iodide is too costly and involves great waste, only 4 ounces of every 100 pounds applied being actually imbibed, and only 15 per cent of this 4 ounces really needed. **The Use of Iodine in Public Water Supplies to Prevent Goiter.** J. W. Ellms. 86–7. During period Sept. 11–Oct. 2, 1923, approximately 75 parts sodium iodide per billion was applied daily to water supply of Rochester. Method of application consisted of suspending the salt in bag, back of dam at entrance to reservoir, entire daily quantity (16.6 pounds) entering reservoir within a few minutes. Sodium iodide content of tap water, gradually increased from 4–5 to 50 parts per billion, and, when treatment was discontinued, gradually decreased, reaching normal content on October 19. Maximum of 50 parts was only maintained 4 days and average was approximately 30 parts. It would cost $12,750 to treat Cleveland water supply of 150 million gallons daily in a like manner for a period of 30 days each year, and it would seem more effective and less expensive to treat the individual directly for simple goiter than to attempt medication of water supply. **On the Application of Iodine to Public Water Supplies.** Clarence Bahlman. 88–9. Discussion of previous papers. Treatment of supply of Cincinnati on the basis of Rochester experiment would cost $10,000 per year, representing an increase of 10 per cent in filter plant operating expenses. Use of iodized salt is considered a more reasonable procedure. **The Seal of Safety Indicates a Good Water Supply.** W. H. Dittoe. Activities of Engineering Division of State Health Dept. in examination of water supplies in communities not provided with public supply are outlined.—*R. E. Thompson.*

Experiences in the Campaign against Goiter among Young Girls above School Age by Means of Iodine Tablets. W. Silberschmidt. Schweizerische med. Woch., July 5, 1923; Bull. mens. office internat. d'hyg. publique, **15**: 1376, 1923. Describes use of chocolate tablets containing 0.5 mgm., I, at rate of one tablet per week for two years. Results good with girls from 15 to 21 years of age, but not so good as with younger children. Advises against too great expectations from use of iodized table salt, which is however, free from danger. Less satisfactory results are to be expected in relieving goiter among adults than among children.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abt.*)

Regarding the Goiter Problem. O. Bayard, Schweizerische med. Woch., July 26, 1923, p. 703, and August 2, 1923, p. 732; Bull. mens. office internat. d'hyg. publique, **15**: 1374, 1924. General paper on goiter, last part of which discusses goiter prophylaxis and rôle of I.—*Jack J Hinman, Jr.* (*Courtesy Chem. Abst.*)

Telechron Electric Position Transmitter. Anon. Water and Water Eng., **25**: 473, 1923. Illustrated description of electric indicating gage, for showing at a distance height of water in reservoirs.—*Jack J. Hinman, Jr.*

Estimation of Carbon Dioxide in Drinking Water. P. Lehman and A. Reuss. Zeit. f. Untersuchung der Nahrungs-und Genuss-mittel, **45**: 227, 1923. Water and Water Eng., **26**: 39, 1924. For combined CO_2, two or three drops of Me orange (aqueous, 0.01 per cent) are added to 250 cc. H_2O and titrated with N/10 HCl. For free CO_2, 200 cc. H_2O are treated with 1 cc. Tillmans and Hueblein's phenolphthalein soln. (0.75 grams in 1 liter C_2H_5OH) and titrated with Na_2CO_2 (2.409 grams per liter) till pink color persists 5 min. at 15–20°C. Schloessinger's formula, recalculated, is used, and a table given of CO_2 in H_2O in mgm. per liter.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Causes and Stoppage of a Typhoid Epidemic. J. Freund and V. Andriska. Leit. f. Hyg., **92**: 311, 1923. Bull. mens. office internat. d'hyg. publique **15**: 1228, 1923. Miskolcz (Hungary), 60,000 population, had 292 cases typhoid during March–May 1922. Epidemiological check incriminated water, though its bacterial count ranged from 150 to 670 per cc., and neither Bact. typhosum nor Bact. coli could be found. Water was chlorinated and after 9 days, epidemic ceased.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Purification of the Waste Waters of Coke Plants. R. Durand. L'Eau, **16**: 115 (October 15, 1923.) Fish killing in the Marne was charged to waste from coke plants, found to contain phenol, HCN, and H_2S. It was slightly toxic. Treatment with javel water was found to remove satisfactorily both H_2S and HCN.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Goiter and Lack of Iodine in Potable Water. Cheinisse. La Press Medicale, **44**: 919, 1923. Bull. mens. office internat. d'hyg., publique, **15**: 1239, 1923. Articles of McClendon and Williams confirm work of Chatin in 1852.—*Jack J. Hinman, Jr.*, (*Courtesy Chem. Abst.*)

The Influence of Hydrogen Ion Concentration on the Dose of Alum and the Mechanism of the action of Alum in the Clarification of Natural Waters. NAN LAL BANERJI. Indian Journal of Medical Research, **11**: 3, 695–718, January, 1924. Study of water of Hooghly river, supplying Calcutta, which does not agree with results of Morison who used the softer waters of Poona in his work (Indian J. Med. Res., **3**: 4, 565, 1916) Banerji concludes: (1) Other factors, such as amount of suspended matter, size of particles, conc'n of electrolytes, etc. remaining constant, optimum dose of alum increases, as pH increases, and decreases, as pH decreases; (2) Total hardness plays important part in regulating dose; (3) Mechamism of the reaction may be divided into two parts: (a) Unhydrolysed $Al_2(SO_4)_3$; (b) Hydrolysed $Al_2(SO_4)_3$; made up of H_2SO_4 and Al $(OH)_3$. The positive Al ion from the unhydrolyzsed portion is most potent factor in clarification. Next comes the H ion, and last and least is the Al $(OH)_3$ sol; (4) Dose of alum can be decreased by preliminary addition of a cheap acid such as H_2SO_4. Dose of acid should be regulated so that pH will not be far from 7.0. Increase in dose of alum allows decrease in amount of acid. It is suggested that economy might be secured by treating mud from filters with acid, to dissolve $Al(OH)_3$, and using the acid solution to acidify alum solutions being applied to water.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Removal of Acid, Manganese, and Bacteria from Drinking Water and the Bacterial Purification of Swimming Pool Water. W. OLSZEWSKI. Berichte deut. Pharm. Gesellschaft, **33**: 168–177, 1923; Wasser und Abwasser, **18**: 337, 1923. Removal of aggressive H_2CO_3 is accomplished by aëration or $CaCO_3$. Hard water is best aërated. In removal of Mn by filtration through MnO_2, there must be a sufficient layer of fine MnO_2. Prior chlorination of water cannot be done if biological manganese removal is to be attempted. Recommends rapid sand filtration and Cl for bacterial removal. For pools chlorination is necessary in addn. to filtration. Uusally have 0.2 to 0.5 p.p.m. excess Cl. Dropping Cl dosage means quick falling off in the quality of the pool water.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Simple Method of Well Disinfection. RICHARD WINDISCH. Berliner tierärtzliche Wochenschrift, **39**: 17, 189, 1923. Wasser und Abwasser, **18**: 9, 266, September 8, 1923. Adds large dose of unslaked lime (several hundredweights) and pumps out well after 8 days, repeating every few days until taste is normal.—*Jack J. Hinman, Jr.*

Utilization and Protection of Springs. F. DIENERT. Annales d'hygiene publique, industrielle, et sociale, **1**: 581, 1923. Bull. mensuel office internationale d'hygiene publique, **16**: 105, Jan. 1924. Details the contant supervision exercised over spring water supplies of Paris. In fissured rocks, contamination may be carried as far as 10 to 15 km.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Campaign against Typhoid Fever in Belgium. DR. VAN BOEKEL. Bulletin mensuel office internationale d'hygiene publique, **16**: 22–59, January, 1924. General review of the situation from many angles.—*Jack J. Hinman, Jr.*

Experiences with the Use of a Jewell Filter on River Water in the Tropics. G. Korthoff. Geneesk. Tijdschrift voor Nederlandsch Indie, 62: 359–362, Wasser und Abwasser, 18: 259, September 8, 1923. Filter was washed with raw water. Found that germ-free water was not obtained and that it was inadvisable to attempt to leave the operation to inexperienced help.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water for the English Expedition in Palestine. Ed. Imbeaux. Rev. d'Hyg., 46: 125–135, February, 1924. Description of work undertaken by British Army. Largely details of construction.—*Jack J. Hinman, Jr.*

Filtration, Chlorination and Recirculation of Swimming Pool Water. Dr. B. Burger. Veröf. deut. Gesesellschaft für Völksbader, 7: 1922; Wasser und Abwasser, 18: 342, December, 1923. Rapid sand filters and Cl are used at Berlin-Neukölln swimming pools, and equipment operated 24 hrs. per day. After 18 days use, chlorides had risen from 60 to 88 p.p.m. Water, yellow at start, became clear and colorless. Odor of the bath was destroyed without Cl being noticeable.—*Jack J. Hinman, Jr.*

On the Living and Dead Suspended Matter of the Chlorinated Swimming Pool Water. J. Wilelmhi. Verof. deut. Gesellschaft für Völksbader, 7: 1922; Wasser und Abwasser, 18: 342, December, 1923. The Berlin-Neukölln pool when containing 0.35 p.p.m. free Cl showed no green algae or other plants to be living. Amoebae were present, but other animal forms were limited to worms. The suspended material included hair, epithelial cells, etc. Preliminary baths are necessary.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Scale-Formation and Corrosion in Boilers. Allan A. Pollitt. Chem. Age (London), 7: 76–8, 1922. From Chem. Abst. 16: 3151, September 20, 1922. Effect of impurities in boiler feed water and mechanism of corrosive reactions responsible for deterioration of boiler tubes and plates discussed.—*R. E. Thompson.*

Investigation of Various Varnishes and Paints in Regard to their Rust-Preventive Properties. Maass and Junk. Z. angew. Chem., 35: 353, 360–3, 1922. From Chem. Abst., 16: 321. September 20, 1922. Various substitutes for linseed oil such as cumarone resins, tar oils, phenol-aldehyde products, etc., are generally unsatisfactory. Tests were made on tar oil preparations and "Imprex" varnishes (manufactured by G. Ruth, Wandsbek) made from linseed oil with addition of inert colloidal thickening agent which effects a saving of up to 70 per cent of the oil. Boiled linseed oil showed greater permeability to water and less protection against rusting then the other oils: in other respect tar oil preparations were decidedly inferior. One of the Imprex varnishes had excellent elasticity, durability, and impermeability, and, on account of its high spreading rate, is very economical and serviceable for certain purposes.—*R. E. Thompson.*

Miscellaneous Exposure Tests. H. A. Gardner. Paint Manfrs. Assoc. of U. S., Circ., 152: 282–313, 1922. From Chem. Abst., 16: 3216, September 20, 1922. Brush and spray coats showed equal durability on three years exposure. Examination of paints containing titanium oxide and exposed for 20 months, showed this pigment, in combination with zinc oxide and an inert other than whiting, to give good results. Paints exposed in Texas sulfur regions composed of titanium oxide, lithopone, zinc oxide and inerts were in very good conditions after 10 months, while those containing leaded zinc were badly discolored but regained their original whiteness when the sulfur plant was out of commission.—*R. E. Thompson.*

Forces of Adhesion in Solution. II. Coagulation of Coarse Suspensions. S. Wosnessensky. Kolloid-Z., 33: 32–4, 1923: cf. C. A., 17: 1572. From Chem. Abst., 17: 3437, November 10, 1923. Single electrolytes, with exception of calcium and barium hydroxide did not have coagulating effect on coarse suspensions of kaolin, alumina and antimony oxide. Marked coagulation occurs with simultaneous action of bivalent or trivalent metal salts and caustic alkalies, e.g., barium chloride and sodium hydroxide or aluminium chloride and sodium hydroxide. These materials form difficultly soluble hydroxides which are adsorbed on the surface of particles of suspension and cause coagulation by changing forces of adhesion and cohesion. Materials such as ammonium chloride and tartaric acid which hinder formation of hydroxides disturb the coagulation. The thickness of the adsorbed hydroxide is estimated to be of molecular dimensions.—*R. E. Thompson.*

The Limits of Hydrogen Ion Concentration as Determined by Electrometric Titrations in Water Solutions of Carbon Dioxide, Calcium Sulfate, and Calcium Carbonate. J. W. Shipley and I. R. McHaffie. J. Soc. Chem. Ind., 42: 311–9 T, 1923. From Chem. Abst., 17: 3440, November 10, 1923. Data given on electrometric titration of calcium hydroxide and carbonate with sulfuric acid and carbon dioxide. The pH values of mixtures of calcium carbonate and sulfate and carbon dioxide varied from 9.38, value for saturated calcium carbonate, to 3.96, value for saturated carbon dioxide. With all three substances present the value remained practically constant at 5.11. In absence of calcium sulfate it did not fall below 6.56: hence calcium sulfate increases acidity of water containing calcium carbonate and carbon dioxide. In absence of calcium carbonate, pH value of saturated carbon dioxide was same whether calcium sulfate was present or not.—*R. E. Thompson.*

The Bicarbonate Equilibrium. J. W. Shipley and I. R. McHaffie. J. Soc. Chem. Ind., 42: 319–20T; 321–6T, 1923. From Chem. Abst., 17: 3441, November 10, 1923. Hydrolysis of saturated calcium carbonate solution calculated to be 8 or 10 per cent. This is much lower than values obtained by previous investigators. Solubility products of calcium carbonate and hydroxide at 20° were found to be 1.15×10^{-8} and 0.64×10^{-5}, respectively. Constant for ionization of H_2CO_3 into H^+ and HCO_3^- was found to decrease with dilution; while that for ionization of HCO_3^- into H^+ and CO_3^{--} increases with dilution and the product $H^+ \times CO_3^{--}$ is independent of dilution. The

proportion of dissolved carbon dioxide which is present as carbonic acid varies directly as the dilution.—*R. E. Thompson.*

The Melting Point of Ice on the Absolute Temperature Scale. L. B. Smith and R. S. Taylor. J. Am. Chem. Soc., 45: 2124–8, 1923. From Chem. Abst., 17: 3444, November 10, 1923. Value of absolute temperature of melting ice from volume coefficient of N_2 is found to be 273.159° and from pressure coefficient 273.097°. Mean value obtained by using data of other gases including Joule-Thomsen coefficient is 273.13° ± 0.01°.—*R. E. Thompson.*

Composition of the Precipitate from Partially Alkalinized Alum Solutions. L. B. Miller. U. S. Public Health Reports, 38: 1995–2004, 1923. From Chem. Abst., 17: 3461, November 10, 1923. Varying amounts of sodium hydroxide were added to alum solutions 0.005 and 0.02 molar in aluminum, at room temperature and, to latter, at 100°. For additions of sodium hydroxide up to 2.5 molecules per molecule of aluminium at room temperature, composition of precipitate was constant and approximated Williamson's $5Al_2O_3 \cdot 3SO_3$. Increasing concentration of SO_4 ion over wide range, by addition of potassium sulfate or ammonium sulfate, or increasing aluminum concentration up to 0.1 molar had no effect on composition of precipitate formed at definite pH. The precipitate appears to consist of two components of nearly equal solubility. For 0.005 molar concentration greatest insolubility of precipitate was found at pH 6.7–7.0, at which point 2.75 molecules of sodium hydroxide have been added. On both sides of this, pH 5.4 and 8.5, are zones of great insolubility. Theriault and Clark's point of greatest flocculation, pH 5.5 (2.4 molecules of sodium hydroxide added), is point where precipitation first approaches completion and is in region where greatest SO_4 is found in precipitate. In Blum's method for aluminum determination it is esssential that SO_4 be absent or present in small amount. If present in large amount second precipitation from hydrochloric acid solution is necessary. Chloride is satisfactorily removed by ten minutes ignition over Meker burner.—*R. E. Thompson.*

The Purification of Water from Standpoint of Feeding Non-Corroding and Non Incrusting Water to Coolers. Alexandre. Chaleur et Industrie, 3: 1853–8, 1922: Chimie et Industrie, 10: 276, 1923. From Chem. Abst., 17: 3556, November 10, 1923. Review and discussion of merits and demerits of various processes for purification of boiler feed water.—*R. E. Thompson.*

Studies on Salt Action. VIII. The influence of Calcium and Sodium Salts at Various Hydrogen-Ion Concentrations upon the Viability of Bacterium Coli. IX. The Additive and Antagonistic Effects of Sodium and Calcium Chlorides upon the Viability of Bacterium Coli. C. E. A. Winslow and I. S. Falk. J. Bact., 8: 215–44, 1923; cf. C. A., 17: 3052. From Chem. Abst., 17: 3522, November 10, 1923. pH 6.0 most favorable to viability. A 0.0145 molar sodium chloride solution and 0.00145 molar solution of calcium chloride were favorable to viability. Sodium chloride solutions of over 0.725 molar strength and calcium chloride solutions of over 0.435 molar strength were toxic at all reactions.—*R. E. Thompson.*

Nitrogen and other Substances in Rain and Snow. J. H. Woehlk. Chem. News, 127:30, 1923; cf. C. A., 16:3993. From Chem. Abst., 17:3558. November 10, 1923. Details of analysis of 12 snows and 29 rains at Mount Vernon, Iowa (October 1, 1922,–June 1, 1923) given. Parts per million: chlorine varied from 3.54 to 28.1: nitrogen averaged 0.896 and was quite constant: average free ammonia was 0.34, albuminoid ammonia 0.264, nitrogen as nitrates 0.346, as nitrites 0.397, and sulfur as SO_3 0.147.—*R. E. Thompson.*

The Mineral Waters of Aix-les-Bains and of Marlioz (Savoie). D'Arsonval, F. Bordas and Touplain. Ann. fals. 16: 268–86, 1923. From Chem. Abst., 17: 3557, November 10, 1923. Two springs at Aix-les-Bains (so-called "alum" and sulfur springs) and three springs at Marlioz (Esculape, Bonjean, Adelaide) are described. The composition, in grains per gal., of "alum," "sulfur," Esculape and Bonjean springs, respectively, are: iron, traces; aluminium, 0.0014, 0.0018, 0.00402, 0.00461; manganese, trace, trace, none, none; calcium, 0.0924, 0.1112, 0.11696, 0.09411; magnesium, 0.020, 0.0222, 0.014, 0.0137; potassium, 0.0028, 0.0020, 0.00635, 0.00804; sodium, 0.025, 0.0248, 0.0624, 0.0552; chlorine, 0.0199, 0.0248, 0.041, 0.040; bromine, none, none, 0.00001, 0.00002; iodine, none; silica, 0.0249, 0.0333, 0.0367, 0.04048; SO_4, 0.130, 0.1677, 0.1836, 0.1775; sulfur, none; S_2O_3, none; phosphoric acid, traces; CO_3, 0.1901, 0.163, 0.125, 0.115; arsenious acid, none; nitrates, none; nitrites, none.—*R. E. Thompson.*

Boron as a Specific Constituent of Certain Mineral Waters. F. Bordas and F. Touplain. Ann. fals., 16: 356–60, 1923. From Chem. Abst., 17: 3557, November 10, 1923. Flame and turmeric paper methods of detecting boron described. The sensitiveness of the former is approximately 0.03 milligrams of boron. It is suggested that boric acid be used instead of fluorescein in tracing subterranean course of springs.—*R. E. Thompson.*

Production of Alkalinity by Bacteria as Registered by Different Indicators. J. A. Reddie. J. Soc. Chem. Ind., 42: 326–32T, 1923. From Chem. Abst., 17: 3558, November 10, 1923. Filtration usually reduces alkalinity of sewage, which is normally in neighborhood of 300 p.p.m. At Bradford the reverse is true. The increase was found to be independent of type of filter used and is attributed to the high protein content of the Bradford sewage.—*R. E. Thompson.*

The Disposal of End Liquor at the Beinerode Potash Works. Ernst Fulda. Kali, 17: 146–50, 1923. From Chem. Abst., 17: 3558, November 10, 1923. End liquor is pumped into abandoned and flooded shaft in mountain composed largely of conglomerate, segmented gypsum. Estimated that this deposit will absorb at rate of 120,000 cu. m. per year, end liquor produced by works for 390 years.—*R. E. Thompson.*

Aluminum Hydroxide. I. Hydrates and Hydrogels. Richard Willstatter and Heinrich Kraut. Ber., 56B: 149–62, 1923. From Chem. Abst., 17: 3513, November 10, 1923. Alumina prepared in different ways, details of

which are given, was used to determine whether cause of variation in activity as adsorbent is formation of chemical compounds, and whether adsorption activity and chemical properties are so related as to differentiate kinds of alumina. When invertase prepared from yeast was used, adsorption value of aluminum hydroxide was increased many times by dilution. There seemed to be no simple relation between colloidal properties and adsorption activity of aluminum hydroxide gels.—*R. E. Thompson.*

The Present Status of Water Purification in Iowa. Jack J. Hinman, Jr. Proceedings, Thirty-fifth Annual Meeting, Iowa Engineering Society, Des Moines, January 23–6, 1923. Water purification in Iowa reviewed and methods of control employed by State Department of Health outlined. There are approximately 500 water plants in the state, of which 52 attempt complete purification. Forty-eight chlorinate. Higher percentage of good samples obtained from treatment plants than from any other source of supply, public or private. Of public supplies, percentage of good samples is least from springs and shallow wells, while deep wells are intermediate between these and treated waters. Charts included showing location of purification plants, growth of purification since 1890, and conditions of water samples classified by sources. Data on essential features and purification effected at 23 plants given.—*R. E. Thompson.*

Cardiff Water Works Undertaking. N. J. Peters, H. W. B. Cottrill and B. Santo Crimp. Municipal Engineering, 72: 702, 1923. Brief outline of papers presented at Public Works Conference, London, Eng. System of rough filtration will be installed to prevent incrustation and growth in conduit from impounding reservoirs.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Adsorption of Organic and Inorganic Colloidal Electrolytes. M. A. Rakuzin. J. Russ. Phys. Chem. Soc., 53: I, 357–68, 1921. From Chem. Abst., 17: 3635, November 20, 1923. Alumina irreversibly adsorbed 44 per cent of gum arabic from solution in 48 hours. Colloidal solutions of potassium silicate and sodium fluorosilicate were reversibly adsorbed, being partly recoverable by boiling with water.—*R. E. Thompson.*

An Improved Methyl Orange. J. Moir. J. S. African Chem. Inst., 6: 69–70. 1923. From Chem. Abst., 17: 3652, November 20, 1923. New indicator, *p*-sulfo-*o*-methoxybenzeneazodimethyl-α-naphthylamine, described. Changes from deep yellow to red-purple in artificial light and from orange to blue-violet in daylight. pH range is from 4.9 to 3.5. With tap water it showed alkalinity of 13.5 CaO compared with 14 with methyl orange. With greater alkalinities, the values were same. Is more satisfactory than methyl orange in artificial light.—*R. E. Thompson.*

An Apparatus for Electrometric Titrations. A. J. Pelling. J. S. African Chem. Inst., 6: 40–8, 1923. From Chem. Abst., 17: 3630, November 20, 1923. Satisfactory form of apparatus for H-ion titrations. Use in titrating mine waters described.—*R. E. Thompson.*

The Influence of Alcohol on the Sensitiveness of Dye Indicators. I. M. Kolthoff. Rec. Trav. chim., 42: 251–75, 1923. From Chem. Abst., 17: 3652, November 20, 1923. Eighteen indicators were investigated. Concluded that indicators that act like acids become more sensitive to H-ions in presence of ethyl alcohol, regardless of whether indicator is acid- or alkali-sensitive.—*R. E. Thompson.*

The Use of the Quinhydrone Electrode in Place of the Hydrogen Electrode in Potentiometric Acidity Determinations. I. M. Kolthoff. Rec. Trav. chim., 42: 186–98, 1923. From Chem. Abst., 17: 3654, November 20, 1923. Quinhydrone electrode of Granger discussed. Advantages over hydrogen electrode are: more easily prepared; potential quickly established; may be used in solutions in which hydrogen electrode is useless, such as solutions of metallic salts, alkaloid salts, etc.—*R. E. Thompson.*

Volumetric Method for Determination of Magnesium. M. Bulli and L. Fernandes. Ann. chim. applicata, 13: 44–5, 1923. From Chem. Abst. 17: 3655, November 20, 1923. Precipitation of $Mg(NH_4)_2Fe(CN)_6$ from solutions containing Mg^{++} and $Fe(CN)_6^{-- --}$ in presence of ammonium salts utilized for determining magnesium volumetrically.—*R. E. Thompson.*

Colorimetric Determination of H-Ion Concentration by the Method of Michaelis with One Color Indicators, with Inorganic Solutions for Color Comparison. I. M. Kolthoff. Pharm. Weekblad, 60: 949–66, 1923. From Chem. Abst., 17: 3654, November 20, 1923. Optimum pH ranges found were: 2, 6-dinitrophenol, 2.0–4.0; 2, 4-dinitrophenol, 2.6–4.4; 2, 5-dinitrolphenol, 4.0–5.8; p-nitrophenol, 5.6–7.6; m-nitrophenol, 6.8–8.6; phenolphthalein, 8.0–10.0; salicyl yellow, 10.0–12.0.—*R. E. Thompson.*

Volumetric Method for the Determination of Potassium. M. Bulli and L. Fernandes. Ann. chem. applicata, 13: 46–8, 1923. From Chem. Abst., 17: 3655, November 20, 1923. The complex compound $K_2Pb(Co(NO_2)_6$ (cf. Cuttica, C. A. 17: 3000) used for precipitating and determining potassium indirectly by volumetric method.—*R. E. Thompson.*

Electrolytic Protection of Condenser Tubes. A. B. Technique moderne, 15: 567–8, 1923. From Chem. Abst., 17: 3671, November 20, 1923. Discussion of cause of corrosion of marine engine condensers and its prevention or retardation by passage of electric current. For new condenser tubes and corrosive water it is advisable to use high amperage for few days until a thin film of calcium carbonate (few tenths of mm.) is formed and then reduced to about 3 amps.—*R. E. Thompson.*

Water Purification. W. F. Langelier. U. S. (Patent) 1,465,137, August 14. From Chem. Abst., 17: 3734, November 20, 1923. Water or sewage to be purified is treated with soluble aluminium salt such as aluminium sulfate and with sufficient hydrochloric, sulfuric or other acid to give pH which will assist coagulation and sedimentation.—*R. E. Thompson.*

First Experimental Report to the Atmospheric Corrosion Research Committee of the British Non-Ferrous Metals Research Association. W. H. J. Vernon, Pp. 62 (Presented to Faraday Society, December 17, 1923.) Chem. Ind., 43: 13, 339, March 28, 1924. Work was carried out at Royal School of Mines, South Kensington. Metal plates, measuring 10 cm. square with either polished or matte (emeried) surfaces, were exposed to four different types of atmosphere: (1) always unsaturated with water vapour; (2) moisture content from time to time reaching saturation value; (3) containing gas combustion products from cooking and lighting; (4) external air on roof of Royal School. Curves showing relation between weight increment (W) and time (t) have been plotted in many cases. Three types of curves may be distinguished: (1) those in which rate of increase falls off with time, as surface-film becomes thicker and obstructs access of tarnishing agent to unchanged metal beneath; (2) those in which rate of increase does not alter with time. (3) those in which rate of attack increases with time. Iron specimens kept in tank-room rusted at a rate which increased as rust accumulated.—*A. M. Buswell.*

Effect of Excess Air on Flue Temperatures and on Efficiency.. A. K. Bak. Power, 59: 17, 635, April 22, 1924. Air quantity has important bearing on boiler losses and efficiency. Variation in quantity has direct effect upon mass of flue gas discharged and also gives rise to changes in flue gas temperature. Results of tests at Conners Creek Plant of Detroit Edison Co., establish relation between excess air and stack gas temperature for that particular boiler and setting.—*Aug. G. Nolte.*

Relative Merits of Different Types of Motor Bearings. F. E. Boyd. Power, 59: 17, 641, April 22, 1924. Relative merits of ball, roller, and sleeve bearings, from user's viewpoint, are discussed.—*Aug. G Nolte.*

Development of the 12000 Horsepower Nürnberg Diesel. W. Laudelin. Power, 59: 17, 642, April 22, 1924.—*Aug. G. Nolte.*

Water Treatment at Cahokia. E. H. Tenney. Power, 59: 17, 647, April 22, 1924. The various uses for which water was required in operation of Cahokia Plant of Union Electric Light and Power Co., on east bank of Mississippi River, opposite St. Louis, called for design of a treating system to purify the raw river water. Author illustrates and describes the purification system and gives characteristics of the raw water.—*Aug. G. Nolte.*

Some Methods of Storing Coal. Power, 59: 3, 96, January 15, 1924. Several low-priced systems for storing coal mechanically are discussed.—*Aug. F. Nolte.*

Maintaining Quality of Steam Turbine Oils in Service. C. H. Bromley. Power, 59: 4, 125, January 22, 1924. Discusses principal factors in recent developments of information and equipment as related to maintaining quality of lubricating oils in use in steam turbines. Effects of oxidation, heat and air on oil. Several systems for purification of oil illustrated and described.—*Aug. F. Nolte.*

The Locomotive Crane as a Coal-Storage Machine. Power, 59: 4, 133, January 22, 1924.—*Aug. F. Nolte.*

Coal-Storage Systems for Large Plants. Power, 59: 5, 172, January 29, 1924. Various systems for storage of coal are illustrated and described.—*Aug. G. Nolte.*

Boiler-House Efficiency. J. T. Beard, 2nd. Power, 59: 5, 168, January 29, 1924. Analyzes factors entering into combined, or over-all, efficiency of a boiler; points out how they are related to one another; shows how they are influenced by design of the equipment; and indicates what steps may be taken to increase efficiency by prevention of excessive losses.—*Aug. G. Nolte.*

Application of Various Types of Coal-Handling Equipment. G. E. Titcomb. Power, 59: 5, 189, January 29, 1924. Abstract of a paper presented before Metropolitan Section, A. S. M. E., of New York City on January 22, 1924.—*Aug. F. Nolte.*

Accelerating the Softening of Water. Maschinenbau-A.-G. Balcke. G. P. 381,042, 8.5.21. Chem. Ind., 43: 20, B 398, May 16, 1924. High velocity is imparted to water after it has been treated with softening agents, and is subsequently reduced by means of baffles or the like; whereby separation of precipitated material is accelerated. Apparatus comprises turbine-like device with baffles disposed around its periphery and lower part, enclosed in a receptacle, open at the bottom, mounted in a sludge-separating chamber covered at the top by a filter. The raw water is introduced through pipe passing downwards through the filter.—*A. M. Buswell.*

Hydrotitrimetric Analysis. (Determination of Hardness of Water.) N. Tarugi and G. Gasperini. Boll. Chim. Farm., 1924, 63, 33–38, 65–70. Chem. Ind., 43: 18, B 350., May 2, 1924. One of principal causes of inaccuracies attending use of Boudron and Boudet's modification of Clark's method for determining hardness of water lies in nature of the solution used, this consisting of an aqueous alcoholic solution of a mixture of sodium oleate, palmitate, and stearate, which do not always behave similarly towards alkaline—earth salts. The use of stearate solution being inconvenient, owing to the relatively low solubilities of both sodium and potassium stearates, and consequent tendency of solutions to form deposits in cold weather, the use of potassium palmitate solution is recommended for determining hardness of waters.—*A. M. Buswell.*

Separation of Impurities from the Wash-Water of Filters. B. Bramwell. E. P. 211, 307, 11. 1. 23. Chem. Ind., 43: 18, B 351, May 2, 1924. The wash water is delivered to settling tank with V-shaped bottom or to a pair of these tanks, communicating at farther end. The deposited solids are raised by travelling elevator of bucket type and discharged into narrow shallow sludge channel alongside. Effluent is filtered and used again for washing of filtering material.—*A. M. Buswell.*

Manufacture of Water Softening Materials. S. V. H. Lassen and United Water Softners, Ltd. E. P. 211,240, 14.2.23. Chem. Ind., **43**: 18, B. 351, May 2, 1924. Artificial zeolites and similar base-exchanging compounds are rendered resistant to disintegration and to solvent action of acid waters, by a process of thorough drying followed by hydration. The precipitates, prepared by interaction of suitable salts, are slowly dried at 80°–100° until no further loss in weight occurs. While in form of comparatively large lumps, material is then subjected for some hours to current of mixture of air and steam. Proportion of steam to air is small at first and is gradually increased as hydration proceeds. Water-softening materials prepared by fusion processes may be similarly hydrated.—*A. M. Buswell.*

Allen Salt Velocity Method of Measuring the Flow of Water. Power, **59**: 18, 683, April 29, 1924. Article is based on paper by C. M. Allen and E. A. Taylor, presented at annual meeting of American Society of Mechanical Engineers, December 3 to 6, 1923. In measuring flow of extremely large quantities of water, such as in hydro-electric plants, it is general practice to measure rate of flow through penstock or canal of known cross-section and calculate volume therefrom. Allen salt-velocity method is simple and accurate way of measuring rate of flow, based on facts that salt in solution increases the electrical conductivity of water, and that if a quantity of salt solution is introduced into fresh water flowing through a pipe, although solution may tend to spread out and mix with water, its point of greatest density will retain practically a fixed relation to rate of flow in pipe. Suppose for example that two sets of electrodes are placed in a pipe line a measured distance apart, and that to each set is connected a source of electric current with an ammeter in circuit; in fresh water, no current will flow and meter will indicate zero. If charge of salt solution is introduced on upstream side of upstream set of electrodes, as it is carried down with current it comes in contact with upstream electrodes: needle of the ammeter is then deflected gradually from zero to a maximum and back to zero again. Later, down-stream electrodes, similar deflections of ammeter on that set will occur. Difference in time between the two maximum readings will be found to represent very closely correct period of flow between the two sets of electrodes. Article describes experimental work in connection with development of the method and shows how a quantity of salt solution may be expected to act, when carried along by a current of water.—*Aug. G. Nolte.*

Finding the Cost of Exhaust as Compared to Live Steam. C. E. Colburn. Power, **59**: 20,759, May 13, 1924.—*Aug. G. Nolte.*

Construction of Boiler Settings in Devon Station. Power, **59**: 20, 763, May 13, 1924. Furnace walls constructed entirely of firebrick. Arches built in walls to relieve loading on brick. Expansion joints filled with asbestos fiber divide walls into vertical sections and allow for horizontal expansion. Vertical expansion provided for by expansion joints under the relieving arches and at lower tube line. No heat-insulating bricks used below lower tube line. Illustrated.—*Aug. G. Nolte.*

How External Air Cooling Increases the Effectiveness of Condenser-Tube Surface. P. Bancel. Power, 59: 20, 769, May 13, 1924.—*Aug. G. Nolte.*

Computing Guaranteed Stoker Efficiency, H. F. Gauss. Power, 59: 21, 813, May 20, 1924; also Power, 59: 22,858, May 27, 1924. Discusses factors entering into computation of stoker efficiency. Typical examples and convenient charts to facilitate computations are given.—*Aug. G. Nolte.*

Application of Motors to Power House Auxiliary Drives. H. L. Smith. Power, 59: 21, 817, May 20, 1924. Types of drives available for various auxiliaries are considered. Reliability of service and simplicity and flexibility of operation should govern the choice.—*Aug. G. Nolte.*

The Testing of Boiler Plates. Dr. C. L. Huston. Power, 59: 21, 821, May 20, 1924.—*Aug. G. Nolte.*

Relative Cost of Water and Steam Power. Power, 59: 21, 827, May 20, 1924. Instructive comparisons between costs of water and of steam power, in paper by Halford Erickson, vice-president of Byllesby Engineering and Management Corporation, before Wisconsin Utilities Association. Construction costs and fixed charges for water plant are, as a rule, twice as great as for steam plant, and overbalance the smaller operating expense. Steam plant has greater reserve capacity and is in position to render better and safer service.—*Aug. G. Nolte.*

The Diagnosis of Diesel-Engine Defects from Indicator Diagrams. R. C. Melrose. Power, 59: 23,898, June 3, 1924. In actual practice, conditions as shown by theoretical diagram (illustrated) are not obtained; because, (1) the water, circulating in jacket, cylinder head, and piston absorb heat during compression and expansion; (2) particles of oil are still burning after fuel valve is closed; (3) the combination of oxygen, carbon and hydrogen does not remain constant; (4) mechanical defects; such as leaking piston rings, exhaust valves, air inlet valves, fuel valves, air starting valves, etc.; (5) effect of high piston speed on volumetric and scavenging efficiencies. Specific defects are discussed and their presence illustrated by indicator diagrams.—*Aug. G. Nolte.*

Pulverized-Fuel Systems. A. L. Cole. Power, 59: 23, 900, June 3, 1924, and Power, 59: 24,940, June 10, 1924. Series of articles describes different types of equipment now in general use for drying, pulverizing, transporting, and burning coal in pulverized form. Some present day types and methods are presented and illustrated.—*Aug. G. Nolte.*

Piping Materials, Valves and Gaskets for High Pressures and Temperatures. J. D. Morgan. Power, 59: 23, 907, June 3, 1924. Data taken from practice. —*Aug. G. Nolte.*

Quantitative Expression of the "Aggressivity" of a Water and the Applicability of De-Acidification Processes. A. Mundlein. Gas-u. Wasserfach, 1924. 67, 161–163, 178–180: Chem. Ind., **43**: 22, B 440, May 30, 1924. Of the free carbon dioxide present in water, a portion serves to hold the bicarbonates in solution, and is termed the natural ("zugehörige") carbon dioxide; the remainder forms the "aggressive" carbon dioxide. Free carbon dioxide can be removed by a current of air. The natural carbon dioxide dissolves iron, whilst aggressive carbon dioxide dissolves both iron and calcium carbonate. Graphs show the relation between hardness and "natural" and total free carbon dioxide and relative rates of solution of iron (curves for $h = 0.25$, $h=0.5$, etc.) and of calcium carbonate (curves 0, 4, 30, 95, and 180). As aggressivity depends upon hydrogen-ion concentration, water with a given total free carbon dioxide content will have an aggressivity dependent upon its hardness; from which it follows that the choice between mechanical and chemical treatment to reduce the aggressivity of a given water will be determined by its hardness and that occasionally both treatments are necessary.—*A. M. Buswell.*

Method for Purifying Water (Softening, and Removing Dissolved Salts). E. Mayer and R. Schon. Oesterr. Chem-Ztg., **27**: 46–47, 1924: Chem. Ind., **43**: 22, B 441, May 30, 1924.—*A. M. Buswell.*

The Construction and Maintenance of Water Facilities at Stock Yards. Anon. Railway Engineering and Maintenance, **19**: 457, 1923. Com. report to Am. Ry. Bridge and Bldg. Assoc. gives detailed recommended practice in supplying water to railway stock yards.—*R. C. Bardwell.*

Pumping Water From a Stream With a Sixty Foot Stage Variation. Robert Herzog. Railway Eng. and Maintenance, **19**: 391, 1923. Detailed plans are shown and explained covering construction of concrete dry well 70 feet deep by Great Northern R. R. at Wenatchie, Wash. Duplicate units consisting of 40 h.p. electric motors direct connected to 4 inches single stage horizontal centrifugal pumps are located in bottom of well on practical low water level. Starting and stopping of pumps is automatically controlled.—*R. C. Bardwell.*

Southern Pacific Completes Million Gallon Pumping Plant. Anon. Railway Eng. and Maintenance, **20**: 105, 1924. The Southern Pacific R. R. installed two wells 870 feet deep at El Paso, Texas, from which water is pumped by air lift consisting of two 200 h.p. oil engines with 1214 cubic feet per minute compressors. Each well delivers 750 g.p.m. and installation is equipped with latest developments in air lift pumping. Photographs and general layout plan are given.—*R. C. Bardwell.*

Burlington Builds 900,000,000 gallon Reservoir. Anon. Railway Eng. and Maintenance, **19**: 481, 1923. C. B. & Q. RR. installed earth dam with creosoted plank core, 700 feet long by maximum height 48 feet, near Galesburg, Ill., impounding 900,000,000 gallons water. Pumping units consist of three electrically driven triplex pumps each delivering 750 g.p.m. through six miles

of pipe line to terminal roundhouse. General plans and photographs are given.—*R. C. Bardwell.*

Construction of Gravel Wall Wells Solves Water Supply Problem. C. R. Knowles. Railway Eng. and Maintenance, 20: 143, 1923. The Illinois Central RR. has completed two gravel wall wells 26 inches diameter by 147 feet deep at Paxton, Illinois, which deliver separately 340 g.p.m. and together 530 g.p.m. Pumps are vertical centrifugal electric driven. General description given of installation and results.—*R. C. Bardwell.*

The Use of Lead as Compared with Substitutes for Joints in Cast Iron Pipe. Com. report, A. R. E. A. Bulletin, 261: 178, 1924. Progress report.—*R. C. Bardwell.*

Use of Treated Wood for Water Tanks. Com. report, A. R. E. A. Bulletin, 261: 185, 1924. Creosoted yellow pine tanks have been found to give satisfactory service for water storage at less cost than untreated wood tanks of high grade lumber.—*R. C. Bardwell.*

Automatic Control of Electrically Operated Pumps. Com. report, A. R. E. A. Bulletin, 261: 174, 1924. General description and principles of automatic starters.—*R. C. Bardwell.*

Publicity Campaign That Helped Gain Public Support. Claude M. Chaplin. Fire & Water Eng., 74: 845, October 17, 1923. Describes and illustrates advertisements of East Bay Water Co., Oakland, Cal., in daily papers, of which about 150 have been published. Fullest coöperation is given daily press when information concerning company is desired. Through authorized channels, company submits to all publications, with circulation in territory it serves, interesting news stories regarding operation, development work, improvements, maintenance and planning for the future.—*Geo. C. Bunker.*

Problems That Confront the Private Water Company. W. W. Colledge. Fire & Water Eng., 74: 895, October 24, 1923. Address before Pittsburgh (Penna.) Chapter National Association of Cost Accountants. In case of water utility company, in order that it may pay fair return on investment, it is not the amount of money it can charge for its product, because that is already fixed, but the amount of money it can save in operating expenses that is to be considered. Unless careful accounting is used and correct management applied, water company game will prove a game of charity so far as stockholders are concerned.—*Geo. C. Bunker.*

Water Earnings Take Care of Improvements and Expenses. D. C. Spencer. Fire & Water Eng., 74: 896, October 24, 1923. Brief notes on municipal water works of Spartanburg, S. C. Water works acquired in 1908 by purchase; today there are 65 miles of mains, 325 hydrants, and 4000 consumers. Pumping equipment consists of two condensing steam pumps of 2 and 3 million gallons capacity, respectively, and of two direct connected motor driven pumps, each

of two million gallons capacity. Filter plant contains 8 units, each of 500,000 gallons capacity, with clear water well of 750,000 gallons capacity, and coagulating basin of 3,000,000 gallons. Raw water storage on Chinquepin Creek has capacity of 6,000,000 gallons. Statement is made that during period of municipal ownership, operation has been self-sustaining and earnings have provided for increase and expansion.—*Geo. C. Bunker.*

Eliminating Water Hammer from a Pressure Regulating Valve. Sydney L. Ruggles. Fire & Water Eng., 74: 947, October 31, 1923. Description of changes made in float and lever attached to 8 inch regulating valve of balanced type which works in pressure reducing chamber under pressure head of 272 feet on one side and 3 feet on other and is connected to pipe line 3 miles long. Changes eliminated water hammer in pipe line and resulting leaks from blown joints, which amounted to as many as 75 in some seasons and occupied repair gang from two weeks to a month each spring, recaulking joints. Illus.—*Geo. C. Bunker.*

Checking up on the Water Works Personnel. Edward F. Frey. Fire & Water Eng., 74: 951, October 31, 1923. Various forms used in keeping records and information concerning personnel of the Department of Water Supply of Detroit, Mich. Illus.—*Geo. C. Bunker.*

How Water Works are Graded as to Fire-Fighting Capacity. Harry J. J. Corcoran. Fire & Water Eng., 74: 991, November 7, 1923. In Iowa, National Board of Fire Underwriters' Standard Grading Schedule is used to grade system in connection with public fire department. The rules of National Board of Fire Underwriters and Central Actuarial Bureau are used in grading value of service for supply to privately owned automatic sprinkler equipments. Water system is examined on three points; adequacy, reliability, and pressures; 32 items are considered independently and sum of the individual charges determines relative class of the system. Under adequacy, normal ability of works to maintain domestic consumption demand and fire flow is considered. In arriving at reliability of system, each step, or operation, necessary in delivering water from source to hydrants is treated separately. In towns and cities larger than 2500 population, supply should be sufficient to maintain fire flow for 10 hours in addition to domestic consumption. Measurement is made on ability of system to deliver fire flow at any pressure down to 20 pounds, this being minimum pressure at which supply is of value for fire streams. Ability to deliver water at pressures sufficient for direct hydrant streams is credited to offset lack of fire department pumping engine capacity; for direct hydrant streams 75 pounds residual pressure at hydrant during flow is necessary for 4-story buildings, 60 pounds is satisfactory for 3-story buildings, and 50 pounds for 2-story buildings and in residence districts. Six-inch is mimimum size pipe for hydrant supply and it should be well cross-connected. Gate valves are very necessary to localize effect of a break; spacing in high value districts should not exceed 600 feet; in other districts, 900 feet. With direct hydrant streams and 3000 gallons per minute required, one hydrant should be installed for each 70,000 square feet; with engine streams and same

quantity, one hydrant for each 100,000 square feet is satisfactory. Hydrants should be able to deliver 600 gallons per minute with a loss of not more than $2\frac{1}{2}$ pounds in hydrant, and total loss of not more than 5 pounds between street main and outlet. Use of public water supplies through privately installed sprinkler systems is on increase. These systems provide most effective fire protection yet developed, and give property so equipped greatly reduced fire insurance rate. Water superintendents should actively encourage their installation. Reports of 28,560 fires in buildings so protected show that 20,234, or 84 per cent, were extinguished with ten or less sprinkler heads opening, or about 300 gallons per minute maximum. Only about 5 per cent required more than 1000 gallons per minute. Value of sprinkler system is entirely dependent upon reliable and adequate water supply. A public supply, to be satisfactory as primary source, must be able to maintain 12 pounds pressure on top line of sprinklers while 500 gallons per minute are flowing from nearest street hydrant. No pipe smaller than 6-inch is of value and in many cases larger pipe is needed.—*Geo. C. Bunker.*

Fuller Reports Great Progress in Water Works Field. George W. Fuller. Fire & Water Eng., 74: 995, November 7, 1923. Progress report of committee on water supply and purification before Sanitary Eng. Section of A. P. H. Assoc. Following subjects are briefly discussed: New projects for water supply; Activity in building of filters, Iodine for combating endemic goitre; Working knowledge of superchlorination and dechlorination; An important legal decision; Corrosive action of water on pipe; Modification of United States Public Health standard; and Adoption of Uniform program in methods of testing water.—*Geo. C. Bunker.*

Water Company Presents Fire Department with Pumper. Fire & Water Eng., 74: 997, November 7, 1923. Shelby Water Co., Shelby, Ohio, presented to city a triple combination fire pumper, in order to be relieved from necessity of boosting pressure every time fire occurs.—*Geo. C. Bunker.*

The Covered Reservoir and Its Advantages. Geo. C. Bunker and A. G. Nolte. Fire & Water Eng., 74: 1043, November 14, 1923. There is no doubt that present day tendency of water works practice is strongly toward covering of new service reservoirs, in which either ground or filtered waters are to be stored, at time they are built; while old uncovered reservoirs are gradually being covered after misdirected influence of amateur water works men, present in every community, has been overcome by practical demonstrations of what it means to interrupt water service of reservoir by frequent cleanings for removing growths of algae. Six very good reasons may be given for covering of service reservoir at time of construction; namely: (1) To maintain water supply in same condition of purity in which it leaves purification plant or ground, by (*a*) preventing entrance of dust, bird droppings, leaves, soot, and other foreign matter, and (*b*) preventing growth of algae. (2) To eliminate frequent cleanings of reservoir, which means that maximum storage capacity of system is always available in case of shutdown of purification plant or pump station. (3) To lessen danger of pollution of reservoir by gang engaged

in cleaning, or by trespassers. (4) To prevent loss by evaporation and to maintain water at uniform temperature. (5) To effect saving in cost of roof which, sooner or later, must be constructed, because it can be built at minimum cost and with no interruptions to water service. (6) Because an uncovered reservoir has no place in a well designed water supply system according to collective expression of engineering judgment. Illus. Cf. this J. 11: 3742.—*Geo. C. Bunker.*

Installing Blind Water Services Before Paving. A. P. Lovell. Fire & Water Eng., 74: 1047, November 14, 1923. In San Diego, Cal., $\frac{3}{4}$-inch lead service pipes are installed on every vacant 50-foot lot and at same time, half inch hole is drilled in curb, directly over service cock, filled with lead and stamped with letter W, so that pipe may be located later on without any trouble. Author considers it advisable to install sealed services previous to new paving, when we can be fairly well assured that it will be unnecessary to cut into new pavement within reasonable length of time. If cast-iron mains are laid with cement joints, and services in lead, many years should elapse before cutting pavement will be necessary. Author's statements concerning dangers of lead poisoning are easily open to misconstruction.—*Geo. C. Bunker.*

Selecting Pumps to Replace Obsolete Types. Frank A. Mazzur. Fire & Water Eng., 74: 1095, November 21, 1923. In making comparisons of various types of apparatus, author has based figures on units of about 3,000,000 gallons capacity in 24 hours, and has considered only plant having good boiler equipment, etc. Types considered are: (1) Steam driven: crank and fly wheel plunger pump; turbine driven centrifugal. (2) Electrically driven; horizontal plunger pump; centrifugal. (3) Oil engine; horizontal plunger pump. Comparison of the operating costs is given for three periods of pumping; 8, 16, and 24 hours per day. Illus.—*Geo. C. Bunker.*

Rainfall and the Recent Water Shortage. Waldo S. Coulter. Fire & Water Eng., 74: 1135, November 28, 1923. Diagram shows cumulative precipitation at Central Park station from December 1, 1922 to October 31, 1923; cumulative curve, representing average for 54 years at same station; cumulative precipitation for 1881 at Philadelphia; and cumulative precipitation on catchment area on Rockaway river above Boonton during 1918. The precipitation by months, for times and places covered by above curves, is shown at bottom of diagram. It is the widespread area affected and the increasing number of supply works operating with limited margin that have made the 1923 drought so disastrous at time of writing.—*Geo. C. Bunker.*

What a Change from Flat Rates to Meter Did for One Town. W. R. Davis. Fire & Water Eng., 74: 1187, December 5, 1923. In Clifton, Arizona, a change was made from flat rate system to meter system in order to prevent expenditure of approximately $80,000 for pumps, mains, new well, etc. Saving in water since meter system has been operative amounts to close upon 50 per cent of quantity furnished the domestic consumer. Cost of change was

$9,000. Tables show amounts of water used by average family in various cities in Arizona.—*Geo. C. Bunker.*

Measuring Large Flows with the Vee-Notch Weir. F. JOHNSTON-TAYLOR. Fire & Water Eng., 74: 1195, December 5, 1923. Description of recorder and integrator for use with this type of weir, both for large and small flows of water. Illus.—*Geo. C. Bunker.*

The Effect of Pressure upon Water Consumption. HUBERT P. MATTE AND JAMES O. G. GIBBONS. Fire & Water Eng., 74: 1231, December 12, 1923. Writers discuss possibility of converting all rates of consumption to their equivalent at some standard pressure, with sufficient degree of accuracy to enable intelligent comparison to be made between different reports of per capita consumption, particularly with view to disclosing cases of excessive leakage and mis-use of water. Assumption is made that water flowing varies as square root of pressure. Venturi chart shows actual water consumption at 45 pounds pressure and equivalent theoretical consumption at 20 pounds.—*Geo. C. Bunker.*

Proposed Water System of New City of Longview. Fire & Water Eng., 74: 1233, December 12, 1923. Description of water system contemplated for new industrial city of Longview in southwestern part of Washington. Present water supply is taken from deep wells and is large enough to take care of 15,000 people. For larger supply it is proposed to build dam across north branch of Goble creek and form reservoir which will have capacity of 400 million gallons an amount sufficient for 45 days' supply for 50,000 people. At foot of mountain, four miles distant from Longview, it is planned to build distributing reservoir of 25 million gallons capacity from which water will be carried through 24-inch cast iron pipe line to two reservoirs, each of 10 million gallons capacity, on hills close to city.—*Geo. C. Bunker.*

When Hot Water Backs into Service Pipes. C. B. JACKSON. Fire & Water Eng., 74: 1237, December 12, 1923. On account of great number of hot water boilers operating on any system, dangers of property loss and also probable loss of life are too great to justify installation of check valves generally. In case there should be occasion to install check valve for purpose of correcting evil known to exist uncorrected by consumer, serving company should by all means give definite notice when such check valve is to be installed. Case of Henri Bourie vs. Spring Valley water Co., 8-California, Appellate Report, page 588, is cited as example.—*Geo. C. Bunker.*

Advantages of the Oil Engine for Water Works Use. F. JOHNSTONE-TAYLOR. Fire & Water Eng., 74: 1244, December 12, 1923. The gas engine is used in Britain for pump operation to large extent. Operating on towns' gas it is ideal standby unit. It can be started up instantly at any time and there is no capital sunk in a producer. In Britain however, towns' gas on account of its cost is rarely used, producers being almost invariably installed. The gas engine—producer combination is a type of prime mover built by numerous

firms in Britain, and, suitable coal being available, is very popular, both at home and in colonies. Well designed gas engine and producer will give one B. H. P. hour on well under $\frac{3}{4}$ pound good anthracite coal. Engineers have come to realize that for small units, steam cannot compare for efficiency with internal combustion engine. Latter has in recent years been vastly improved; especially those of airless injection type. They have all the advantages of the Diesel with none of its disadvantages. The hot bulb engine is also coming into favor on account of its great simplicity, but so far its fuel consumption does not compare with either the Diesel or the four stroke heavy oil engine. The oil engine, in one form or another, presents such outstanding advantages that it would seem that most future developments will take place on these lines. Fuel consumption for pumps driven by oil engines is given for installations in five water works. Illus.—*Geo. C. Bunker.*

Methods and Cost of Thawing Water Services. Eng. Contrg., 61: 560–2, 1924.—*Langdon Pearse.*

Vegetation on Earth Dam Slopes. Bull. Miami Conservancy District, 1923; Eng Contrg., 61: 601, 1924. Experiments with growth on lean soil or gravel show sweet clover and alfalfa the best.—*Langdon Pearse.*

Seasonal Flow in Aqueduct. Eng. Contrg., 61: 601, 1924. The Sudbury, Mass., aqueduct carries more in winter than in summer.—*Langdon Pearse.*

New Well Water System of Winter Garden, Fla. L. H. King. Eng. Contrg., 61: 565–6, 1924. Well installation for 2000 population.—*Langdon Pearse.*

Method of Laying 20-in. Water Main across River. John Taylor. Eng. Contrg., 61: 599–601, 1924.—*Langdon Pearse.*

Experiences with Trench Sheeting. C. R. Gow. Boston Soc. C. E., December, 1923; Eng. Contrg., 61: 596–8, 1924.—*Langdon Pearse.*

Cost of Automobile Operation by a Water Department. Ann. Rep. Water Dept. Pasadena, Cal., 1923; Eng. Contrg., 61: 767, 1924. Cost per hour was $0.19.—*Langdon Pearse.*

Cost of Water Main Construction at Pasadena. Ann. Rep. Water Dept., 1923; Eng. Contrg., 61: 767, 1924. Costs are given for 2, 4, 6, 12, 20 inch pipe in detail.—*Langdon Pearse.*

Flow of Water through Sluices and Scale Model. H. E. Hurst and D. A. F. Watt. Eng. Contrg., 61: 784–5, 1924. Experiments on models of Assuan dam are detailed.—*Langdon Pearse.*

How Gary Water Co. Handle Main Extension. William Luscombe. Ind. San. & W. S. Assn., 1924; Eng. Contrg., 61: 788, 1924.—*Langdon Pearse.*

Welland Water Supply Problem. Willis Chipman. Can Engr., 46: 342, 1924. Recommendations for changes in works necessitated by enlargement of Welland canal.—*Langdon Pearse.*

Extension to Water Works, Brockville, Ont. Can. Engr., 46: 349–50, 1924. Two gasoline driven centrifugal pumps, installed for standby, help reduce coal bill.—*Langdon Pearse.*

Per Capita Water Consumption in Metropolitan Districts. F. E. Merrill. Ann. Water Rep. Somerville, Mass., 1923; Eng. Contrg., 62: 84, 1924. Per capita use of towns in Metropolitan District of Mass. varied from 41 to 127 gallons daily.—*Langdon Pearse.*

An Experimental Study of Air Lift Pumps. C. N. Ward and L. H. Kessler. Bull. Univ. Wis., 9: 4; Eng. Contrg., 61: 1273–8, 1924. Complete details are given of tests, with conclusions and diagrams of loss of head—velocity.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Report on Philadelphia's Water Supply. J. W. Smith, Allen Hazen, G. W. Fuller, J. F. Hasskarl. Pub. Works, 55: 188–9, May, 1924. Recommends turning Torresdale pre-filters into rapid filters, to supply slow sand filters, making thorough double filtration, for half the supply. Recommends storage on Tohickon and Perkiomen creeks, to replace Schuylkill, at cost of $91,500,000, for balance of supply. Provision is made for 500 million gallons per 24 hours from all sources.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Study of Comparative Height Growth of Six Planted Species. H. C. Belyea. Journal of Forestry, 22: 4,389, April, 1924. Field measurements of plantations of Great Bear Water Co., near Fulton, N. Y., planted 1908–10, measured 1923. In order of increasing height Western Yellow Pine, White Pine, Red Pine, Norway Spruce, Siberian Larch, and Scotch Pine. Western Y. P. is not a success. Red Pine appears thriftiest. Observations based on 300 to 750 trees of each species.—*G. R. Taylor.*

Early Development of White and Red Pine Plantations. Ralph C. Hawley. Journal of Forestry, 22: 3, 275–81, March, 1924. Nineteen hundred acres planted by New Haven Water Co., under supervision of Yale School of Forestry. Describes character of land, methods and cost of planting, and measurements of growth. Advises planting more Red than White, because of freedom from insect attacks.—*G. R. Taylor.*

The Erosion Problem. C. G. Bates. Journal of Forestry, 22: 5, 498–505, May, 1924. Discussion of erosion as it affects stream and reservoirs. One stream in flood carried 85,000 cubic yards water and 221,000 cubic yards detritus. Cites experiments on Wagon Wheel Gap, where run-off from denuded watershed has increased 23 per cent since denudation: no decrease in flow of this stream even during summer months. Logging roads, rather than fire, a principal cause of erosion on cut-over areas.—*G. R. Taylor.*

Self Corrosion of Lead Cable Sheath. F. O. Anderegg and R. V. Achatz. Eng. Expt. Station, Purdue University, Bull. 18: 45 pp., July, 1924. Of interest to water works men, as data relative to commercially pure lead sheath are applicable to lead service pipe. Deals only with type of corrosion designated in report of American Committee on Electrolysis as "Self-Corrosion," which is term applied when pipe, or other mass of impure or heterogeneous metal, buried in soil is corroded by electrolysis due to local action, without any external source of current. Self-corrosion may also be due to direct chemical action. Study covers two series of investigations; one in field, and one in laboratory, between the results of which concordance was, in general, obtained. Good understanding of causes and conditions for corrosion was gained and an accelerated test developed which furnishes good indication of probable extent of corrosion in given soil of given sample of sheath material. *Causes of corrosion.* In general, most important cause is presence in soil of organic matter, decomposition of which produces acids tending to attack material of cable sheath. Corrosion product was obtained from about 80 per cent of cables inspected; in nearly every case tests for acetic acid were obtained. Decaying wood and vegetable matter produce this acid; and hence it is inadvisable to use untreated wood boards as protection for cable. Alkali in form of limestone, concrete, gypsum, etc., is also direct cause of corrosion in some cases, and is likely in all cases to increase corrosion rate. Salts, particularly common salt, may also be cause of corrosion, due to local galvanic action. *Factors which increase rate of corrosion.* In general, rate at which corrosion takes place increases with amount of organic matter in soil: a conclusion supported both by field and laboratory observations. In laboratory, order of decreasing corrosiveness was found to be (1) muck, (2) cinders, (3) sand, (4) clay. Corrosion is likely to take place more rapidly in soils containing limestone and other calcareous matter, or where cinders are present. It is more rapid in poorly drained than in well-drained soils. *Effect of sheath compositions.* Both field and laboratory data indicate that tin-lead alloy sheath is much more resistant than pure lead, while antimony-lead, on the other hand, is less resistant. This seems to be due to fact that corrosion starts in intercrystalline spaces. *Prevention of corrosion.* Only means of preventing corrosion is by separation of the cable sheath from soil. In construction using conduit this is done effectively by clay duct, with almost complete absence of corrosion. Limited experience with pitch or asphaltic coverings indicates that corrosion will be prevented if covering complete and continuous. Use of concrete, limestone, or untreated wood, in direct contact with, or in vicinity of sheath, should be avoided. Under discussion of protective covering of cable buried directly in the earth, authors state that among those suggested, or used, are thin covering of sand, wooden strips, building paper, crushed limestone, concrete slabs, etc. Most of companies using buried cable have abandoned use of these protective coverings as they have felt benefit derived from them was not sufficient to justify added cost. Compound recently placed on market which has found wide sale is apparently pitch, or asphaltic substance, with good adherence to cable. As far as is known this type of compound does not contain anything injurious to cable sheath. Similar compounds have been used for sealing potheads for many years without

trouble. If compound is coated over cable in such a way as to prevent direct contact between sheath and soil, it is probable that it will prevent corrosion. Bibliography of 63 papers. Illus.—*Geo. C. Bunker.*

Standard Specifications for Concrete and Reinforced Concrete. Report of Joint Committees. Proc. American Soc. Civ. Eng., **50**: 8, 1153–1285, October, 1924. Comprehensive and detailed specifications covering general conditions affecting use of concrete and reinforced concrete. Affiliated committees of American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering Association, American Concrete Institute and Portland Cement Association.—*John R. Baylis.*

How the Chemical Engineer Tackles the Water Problems of a Railroad. William M. Barr. Chem. and Met. Eng., **31**: 9, 348–51, September 1, 1924. Water treatment for locomotives usually involves precipitation of calcium carbonate. Reactions are reversible, and velocity depends much on temperature and pressure. Reaction temperatures of water when treated range from slightly above 0° to 38°C. Impractical to heat water to hasten reaction. Removal of scale-forming salts is only part of problems; many waters are unsuitable for locomotives after scale-forming ingredients have been removed. Greatest difficulty encountered with water from locomotive engineers' standpoint is foaming, which invariably results is slowing down speed. Good practice to carry water treatment as close to end point as possible without having excess of caustic or carbonate alkalinity. Such treatment results in minimum complaints from locomotive engineers and causes little scale. If dissolved gases could be eliminated and hydrogen-ion concentration held to minimum, corrosion would be small. Possible to run passenger engines 600 to 700 miles in normally bad water districts. Type of softener is of great importance. In order to secure proper settling of sludge, rise of water in softener should not exceed 10 feet per hour. With 30 minutes reaction time and 5 hours settling, some waters can be treated as low as 55 p.p.m. while others will not go nearly so low. Excessive amounts of lime and soda ash are avoided, thus preventing incrustation of injectors and holding foaming tendency to minimum. Zeolite softeners, while giving zero hardness, exchange calcium and magnesium for sodium, thereby increasing foaming tendencies. Cost of sodium aluminate is excessive. Combined with lime and soda ash, it gave hardness of 70 p.p.m. as compared with 90 p.p.m. with straight lime and soda ash.—*John R. Baylis.*

Treating Industrial Wastes. Frank Bachmann and E. B. Besselievre. Chem. and Met. Eng., **31**: 10, 386–7, September, 1924. Industries should bear burden of rendering their wastes harmless before discharging into streams, and treatment of wastes is becoming recognized necessity of plant operation. Type or degree of treatment required depends upon use of the streams receiving discharge. When discharge enters municipal sewer systems leading to plants for sewage treatment, measures must frequently be taken to eliminate constituents that might affect the treatment. In some cases chemical precipitation is absolutely necessary for proper treatment of waste. Removal of sludge may be periodical and manual, or continuous and mechanical. Latter is the more economical method in the average plant.—*John R. Baylis.*

NEW BOOKS

Cours d'Epuration des Eaux et Assainissement des Cours d'Eau. (3e partie du cours hydraulique). DIENERT, 393 pages, 6 figures, 2 plates, L'Ecole Speciale des Travaux Publiques, Leon Eyrolles, director, rue du Sommerard, Paris (5e). 24 francs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Annales des Services Techniques d'Hygiene de la Ville de Paris: Surveillance des Eaux pendent 1922. M. F. DIENERT, chef du srevice. Illustrated brochure, 8vo, 106 pages, Gauthier-Villars et cie, publishers, 55 Quai des Grands Augustins, Paris (6e).—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Notions d'Hydrologie Appliquée a l'Hygiene; Bacteriologie des Eaux. A. GUILLERD, sous chef du Surveillance des Eaux d'Alimentation de Paris, etc. Preface by Dr. F. Bordas, 8vo, 246 pages, 60 figures, Librarie Polytechnique Ch. Beranger, 15, rue des Saints Pères, Paris (6e).—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Pulverised Fuel. W. F. GOODRICH. Charles Griffin and Co. 10s. 10d. 215 pp. Munic, Eng., **73**: 390, 1924. Review.—*R. E. Thompson.*

The Principles of Irrigation Engineering. F. E. KANTHACK. Longmans, Green and Co. 35s. 9d. 299 pp. Munic. Eng., **73**: 696, 1924. Review.—*R. E. Thompson.*

Pulverised Fuel and Efficient Steam Generation. D. BROWNLIE. 184 pp. Munic. Eng. **74**: 103, 1924. Review.—*R. E. Thompson.*

Elements of Water Bacteriology. S. C. PRESCOTT AND C. E. A. WINSLOW. Chapman and Hall. 12s. 211 pp. Munic. Eng., **14**: 178, 1924. Review.—*R. E. Thompson.*

The Use of Copper and Brass for Domestic Water Services. Copper and Brass Extended Uses Council, Birmingham. Munic. Eng., **74**: 220, 1924. Review.—*R. E. Thompson.*

Modern Methods of Pipe Manufacture by the Centrifugal Process. E. J. FOX AND P. H. WILSON. Munic. Eng., **74**: 262, 1924. Review.—*R. E. Thompson.*

Laws Relating to Waters: Sea, Tidal and Inland. COULSON AND FORBES. 4th. Edn. by H. S. MOORE. Sweet and Maxwell., Ltd. £2. 11s. 688 pp. Munic. Eng., **74**: 262, 1924. Review.—*R. E. Thompson.*

A Hundred Years of Portland Cement. A. C. DAVIS. London: Concrete Publications, Ltd. Cloth 21s. 9d. Leather 25s. 9d. 282 pp. Munic Eng., **74**: 393. 1924. Review.—*R. E. Thompson.*